MENSTRUAL CYCLE AND VISUAL INFORMATION PROCESSING

by

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As chair of the candidate's graduate committee, I have read the thesis of Michelle I. Nash in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

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ABSTRACT

MENSTRUAL CYCLE AND VISUAL INFORMATION PROCESSING

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Master of Science

This project examined the effects menstruation may have on visual attention in women. A recent study examined electroencephalographic (EEG) gender differences using a visual object recognition task. Results indicated certain EEG amplitudes (specifically, P300 and N400) are greater in women than men. This study extended the previous findings to determine if these increased EEG amplitudes vary across menstrual phases. Eighteen female participants participated in a series of 3 EEG recording sessions using the same visual object recognition task from the previous study; 18 male participants completed this task once. Analyses from 15 of the 18 female and 16 of the 18 male participants support the previous finding of larger P300 amplitudes in response to relevant stimuli for women compared with men. While there was no distinctive N400 component in this study, there was a late negative (LN) component which was found to vary significantly between men and women. In addition, multiple visual evoked potential (VEP) components varied significantly across the menstrual cycle. In particular, the

N200 component appeared to provide greater differences between menstrual phases than either the P300 or LN components; however, the results varied greatly by head location. The differentiation found with VEP components in response to the pop-out task used in this study provide support for basic visual processing variation across the menstrual cycle and between genders.

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Introduction

Visual Attention

Research in visual attention involves discovering how individuals process and interpret information within their visual field. This includes identifying how cognitive and neural components interact to select certain information and inhibit other information for further internal analysis (Geng & Behrmann, 2003). Visual attention is the quest for how individuals process and interpret information in their visual field. Within this broad area, many theories have been developed regarding how meaningful visual information is discriminated from distracting stimuli. The Feature Integration Theory (FIT) was originally developed by Treisman to account for how visual processing of information occurs. It proposes that information must initially meet certain target criteria before it is selected for further evaluation (Geng & Behrmann, 2003). Treisman (1994) expanded her original explanation of FIT to account for separate attention parallel coding procedures. For example, when participants are given advanced location information, they use an "attention window" to narrow their visual field by selectively searching a specific location; when given advanced information regarding relevant stimuli, participants use inhibition to disregard irrelevant stimuli and make their selection; and when participants are not given any advanced information, they choose an area within their visual field to serially scan until the target stimulus is found.

An interesting phenomenon that occurs in visual attention mechanisms is the "pop-out effect". This automatic response takes place when an object within the visual field has characteristics that make it unique from surrounding objects. This contrast results in the object "popping-out" from the background and immediate attention is

focused on the unique item (Krummenacher & Müller, 2005). Wolfe (2003) has argued that preattentive processes (such as those which result in the pop-out effect) rely on categorical information and enable quick identification of potential objects in a visual scene for more comprehensive analyses. In other words, preattention does not occur independently of normal selective attention processes, but works to enhance the overall search mechanism.

A recent study (Steffensen, et al., 2008) examined event-related potential (ERP) gender differences of the pop-out effect using a visual object recognition task. Participants were asked to distinguish between relevant (diamond shaped), standard (right-facing arrows), and irrelevant (a diamond with a line through it) stimuli presented in a matrix fashion. Results supported previous studies indicating that P300 amplitudes are greater in females than males, but indicated that N400 amplitudes associated with a distracting stimulus were a more sensitive index of gender differences. The gender differences obtained in this study raise the question as to whether hormonal differences across menstrual phases would impact ERP components of females performing this task.

Menstrual Cycle and Cognitive Function

Previous studies that investigated whether hormonal changes are related to cognitive function have produced conflicting evidence. For example, Ussher and Wilding (1991) found that women did not vary in their performance in 15 out of 16 cognitive tasks tested across menstrual phases; only the semantic word processing task improved (during the premenstrual phase). In contrast, a separate study found no variation in performance across menstrual phases for either a semantic decision task or a letter-matching task (Fernandez, et al., 2003). One of the causes of this seemingly conflicting

evidence may be the result of how researchers define menstrual phases and when participants are tested. This presumably is the result of differences in theory with regards to how cognitive function is impacted by the fluctuation of various menstrual hormones. Ussher and Wilding (1991) tested their participants every 3-4 days and divided the menstrual cycle into six phases. Fernandez et al., (2003) tested their participants twice, once during menses and once during the midluteal phase. It may be that performance differences would have occurred if the participants in the Fernandez et al., study had been tested during a different timeframe.

Many other studies have also found no significant differences in performance when evaluating menstrual phases across a variety of cognitive domains; such as paragraph recall (O'Reilly, Cunningham, Lawlor, Walsh, & Rowan, 2004), visual-spatial abilities (Kluck, et al., 1992), auditory discrimination (Fleck & Polich, 1988), and auditory attention (Walpurger, Pietrowsky, Kirschbaum, & Wolf, 2004). Two of these four studies tested women during menses and ovulation; one study tested women during menses, the follicular phase, and the luteal phase; and one study tested women once a week for five weeks. Since women in these four examples were tested over a variety of timeframes, the lack of performance differences might lead one to conclude that menstruation does not impact cognitive performance. However, other researchers have found significant interactions between menstrual phases and cognitive processes. Solis-Ortiz, Guevara, and Corsi-Cabrera (2004) evaluated electroencephalographic (EEG) activity across menstrual phases while participants performed the Wisconsin Card Sorting Test (WCST), which evaluates attention, planning, and adaptation of these skills based on previous experience. Participants performed best during menses and the early luteal phase

and worst during ovulation and the late luteal phase. Another study, measuring the effects of menstruation on cued visual attention tasks, also found variations in performance across menstrual phases with the fastest response times occurring during ovulation (Beaudoin & Marrocco, 2005). These results indicate one of two things; either cognitive tests vary in their level of sensitivity to hormone fluctuations or not all cognitive functions vary as a result of menstrual phase.

Menstrual Cycle and Psychophysiological Trends

While some researchers find no differences in cognitive performance across menstrual phases, they have found evidence of psychophysiological changes across menstrual phase. Although Walpurger et al., (2004) found no significant differences in response times during an auditory attention task, there were significantly longer N200 latencies during follicular and luteal phases compared to menses. Another study also found EEG differences across menstrual phases, with greater P300 amplitudes occurring at menses compared to ovulation regardless of the type of task performed (responding to category words vs. responding to repeat words). This study also found no differences for response time or recognition accuracy across menstrual phases (O'Reilly, et al., 2004). Kluck et al., (1992) also did not find any variation in cognitive performance across menstrual phases with visuospatial tasks and there were no significant changes in ERPs across menstruation; although they did find a trend with P300 components being 15% larger during the fourth week of testing (participants were tested once a week for five weeks). Another study also did not find any significant differences in response times to visuospatial tasks across menstrual phases, nor did the amplitudes of visual ERPs vary across menstrual phase. However, the P300 latency was significantly longer during

ovulation (participants were tested three times a week for an entire menstrual cycle) (Tasman, Hahn, & Maiste, 1999). These findings indicate that hormonal changes across menstruation do impact neural components; however, how these variations affect cognitive functioning in women has yet to be fully understood.

Menstrual Cycle and Emotional Value of Stimuli

Some researchers have suggested that cognitive differences across menstrual phases may be related to the emotional value participants place on a stimulus. One study found no differences across menstrual phases when participants performed a lexical decision task, but found differences in menstrual phases when participants performed a face decision task (Heister, Landis, Regard, & Schroeder-Heister, 1989). When the verbal (lexical) and non-verbal (face) tasks were compared, the fastest verbal and slowest non-verbal reaction times occurred during the premenstrual phase compared to other menstrual phases. Presumably, the face decision task had more emotional value than the lexical decision task and this added complexity required a higher level of processing in participants.

Another study exploring emotional value differences between genders exposed participants to male and female faces and asked them to rate the stimuli based on attractiveness (Juan C. Oliver-Rodriguez, Zhiqiang Guan, & Victor S. Johnston, 1999). Male participants evoked larger P300 amplitudes than female participants overall, however, females evoked larger P300 amplitudes to female faces than to male faces. When women were compared across menstrual phases, researchers found that ERP differences occurred with women in the preovulatory and postovulatory groups compared to women in the ovulatory group, and that these differences were mainly due to ERPs to

female faces. It is difficult to speculate why women would attach more emotional significance to female faces than to male faces.

Other researchers have also found significant differences across menstrual phases with emotion-based tasks. Johnston and Wang (1991) evaluated menstrual cycle hormonal differences and the emotional value of stimuli and found no P300 variations across menstrual cycles when participants viewed neutral stimuli. However, pleasant-rated stimuli (specifically, babies and male models) evoked significantly larger P300 components when progesterone levels were highest (after day 21 of menstruation). In an fMRI study, Amin (2006) found significant activation in response to negative words and happy faces during the follicular phase and in response to positive words and angry faces during the luteal phase. In addition, there was more activation in more cerebral regions during the follicular phase compared to the luteal phase. These particular results are curious in that activation was distinct and apparently polar (negative vs. positive words and happy vs. angry faces) for emotion-related stimuli during different menstrual phases.

The results of these studies suggest that hormone variations across menstrual phases may affect how women perceive and interpret emotionally valued stimuli with most of the differences occurring during the follicular and luteal phases of a menstrual cycle. During these time frames, hormone levels rise with increased estrogen during the follicular phase and high levels of progesterone and estrogen during the luteal phase. Although the present study did not evaluate the effects of emotional stimuli, it is curious to note the results obtained from previous studies on this subject and to speculate that emotional evaluation may impact cognitive processing in women across hormone variations.

Definitions of Menstrual Phases

One of the most noticeable issues among the previous studies reviewed on menstruation is the lack of standardized identification of menstrual phases. Definitions of menstrual phases varied widely, with some studies defining two main phases of menstruation (Amin, 2006; Broverman, et al., 1981; Ehlers, Phillips, & Parry, 1996; Fernandez, et al., 2003; Fleck & Polich, 1988; Hausmann, 2005; Hollander, Hausmann, Hamm, & Corballis, 2005; Kaneda, Ikuta, Nakayama, Kagawa, & Furuta, 1997; Kaplan, Whitsett, & Robinson, 1990; Leary & Batho, 1979; Matthews & Ryan, 1994; O'Reilly, et al., 2004; Postma, Winkel, Tuiten, & van Honk, 1999; Robinson & Kertzman, 1990; Vasil'eva, 2005) and others defining up to six (Ussher & Wilding, 1991). In addition, the length of the various menstrual phases also varied across studies. For example, most studies that defined a follicular phase placed this phase after menses and before ovulation, varying between days 7-15, (Becker, Creutzfeldt, Schwibbe, & Wuttke, 1982; Heister, et al., 1989; Kaplan, et al., 1990; Walpurger, et al., 2004). However, one study included menses as part of the follicular phase and defined this timeframe as days 1-13 (Kaneda, et al., 1997). Furthermore, some studies divided the time occurring after ovulation and before the next menses into several menstrual phases (Basinska-Starzycka, Arnold, Moskwa, Thorell, & Wozny, 2001; Garrett & Elder, 1984; Heister, et al., 1989; Solis-Ortiz, et al., 2004; Ussher & Wilding, 1991), while others did not (Becker, et al., 1982; Hausmann, 2005; Hollander, et al., 2005; Kaneda, et al., 1997; Kaplan, et al., 1990; Krug, Mölle, Fehm, & Born, 1999; Juan C. Oliver-Rodriguez, et al., 1999; Walpurger, et al., 2004; Yilmaz, Erkin, Mavioğlu, & Sungurtekin, 1998); these timeframes also varied a great deal, with phases in some studies overlapping several phases in others. These

variations of menstrual phase definitions may also account for why some studies found significant differences while others did not. For example, Robinson and Kertzman (1990) found no significant outcomes in visuospatial attention when participants were tested on day 25 (participants did respond significantly slower on day 10); while Matthews and Ryan (1994) found participants responded significantly slower during a sustained attention task during the premenstrual phase (days 24-30). However, these differences between studies could also be the result of the type of task performed and may have occurred even if the definitions of menstrual phase were identical.

As previously mentioned, differences of when participants were tested appears to be the result of differences in theory with regards to how cognitive function is impacted by the fluctuation of various menstrual hormones. Some of the studies reviewed seemed to consider ovulation (the time corresponding to when luteinizing hormone levels peak and immediately after estrogen levels peak) to be an important factor in women's cognition, since these studies tested their participants around ovulation and many of them validated that ovulation had in fact occurred within their participants (Beaudoin & Marrocco, 2005; Fleck & Polich, 1988; Krug, et al., 1999; O'Reilly, et al., 2004; Juan C. Oliver-Rodriguez, et al., 1999; Solis-Ortiz, et al., 2004; Vasil'eva, 2005; Yilmaz, et al., 1998). Other studies were more interested with how progesterone affects cognition and tested their participants before and after ovulation (when progesterone levels are low and are high, respectively) and did not test their participants during ovulation per se (Basinska-Starzycka, et al., 2001; Becker, et al., 1982; Broverman, et al., 1981; Ehlers, et al., 1996; Hausmann, 2005; Hollander, et al., 2005; Kaneda, et al., 1997; Kaplan, et al., 1990; Matthews & Ryan, 1994; Robinson & Kertzman, 1990). Once again, results varied

with respect to which phases were significant and which were not and may have been influenced by when participants were tested and/or how menstrual phases were defined.

In addition, verification of menstrual phases also varied across studies. Most relied on self-report measures of menses to identify groups and it is assumed in most of these studies that ovulation occurs on day 14 of a typical menstrual cycle and participants are usually placed in groups accordingly. However, a study of normal healthy women found some ovulated as early as the 9th day while others were as late as the 20th day (Vasil'eva, 2005). Some studies attempted to provide a more accurate means of verifying the menstrual phases by measuring hormone levels; for example, through the use of temperature (Beaudoin & Marrocco, 2005; Becker, et al., 1982; Broverman, et al., 1981; Garrett & Elder, 1984; Kaplan, et al., 1990; Solis-Ortiz, et al., 2004; Tasman, et al., 1999; Ussher & Wilding, 1991; Vasil'eva, 2005), blood draw (Amin, 2006; Becker, et al., 1982; Ehlers, et al., 1996; Fernandez, et al., 2003; Hausmann, 2005; Hollander, et al., 2005; Kluck, et al., 1992; Krug, et al., 1999; O'Reilly, et al., 2004), or urine (Ehlers, et al., 1996; Fernandez, et al., 2003; Kluck, et al., 1992; Krug, et al., 1999; Tasman, et al., 1999). Despite these attempts to validate hormonal levels, there were still large variations in how timeframes were evaluated and groups were identified. These differences create difficulties in trying to compare the results directly between studies; the results of a menstrual phase in one study may overlap with several menstrual phases in another study depending upon how the experimenter(s) divided up their groups. These variations in menstrual phase identification may account for the variety of findings, specifically why some studies had nonsignificant findings.

Present Research

It is obvious from the variety of results found in previous studies that additional research related to hormonal influences on cognitive processes is needed before firm conclusions can be made on the topic. No previous studies addressed visual attention pop-out effects in relation to menstrual phases, nor were any studies on menstruation and cognition found in relation to the N400 ERP component.

This study focused on extending the visual object recognition task used by Steffensen et al., (2008) to determine if the increased P300 and N400 amplitudes they found in women vary across menstrual phases. Since they have demonstrated that the N400 component of the ERP appears to be a more sensitive index of gender than the P300 component, this study hypothesized that it will be a more sensitive index of menstrual cycle effects as well. More specifically, the present hypothesis was that reaction time to the pop-out paradigm and ERP-evoked P300 and N400 amplitudes and latencies will vary significantly across menstrual phases.

Methods

Participants

Eighteen female and 18 male participants were recruited from Brigham Young University undergraduate psychology and neuroscience classes and from the local community via announcements and flyers. Participants were screened to ensure they were between the ages of 18 to 30 years, in good overall health, with no personal history of physiological or psychological disorders, and weren't taking any long-term medication (excluding oral contraceptives). Female participants were further screened to ensure they've had normal menstrual cycles (defined as lasting between 25 to 35 days) for the previous three months and haven't been pregnant or breastfeeding for the previous six months. In addition, female participants were also screened to identify whether or not they were currently taking oral contraceptives (n = 2).

Female participants were asked to participate in a series of three 60-minute EEG recording sessions which would take place during their menses, ovulation, and post-ovulation phases. Male participants were asked to participate in a single EEG recording. Female participants were compensated at $25.00 per session, for a total of $75.00 each. Male participants were compensated with a $5.00 gift card for the campus bookstore.

All 36 recruited individuals fully participated in the EEG sessions; unfortunately, two of the participant files (one male and one female) were unable to be retained due to equipment malfunctions at the time of recording. This particular female participant's other EEG session files were discarded from data analysis. In addition, two participant's files (one male and one female) were discarded due to a high amount of response errors to the non-target stimuli (determined as more than 2 standard deviations above the mean;

male M = 2.24 errors, SD = 3.07; female M = 1.15 errors, SD = 1.46) and one additional female participant's files were discarded due to a different sampling rate with one of her sessions. As a result, 16 of the original 18 male participants and 15 of the original 18 female participants were used for data analysis. Female participants ranged in age from 19 to 29 years (M age = 21.7 years, SD = 2.9 years) and male participants ranged in age from 21 to 30 years (M age = 24.3 years, SD = 3.1 years). Twenty-five participants were Caucasian (fourteen male and eleven female), three were Asian (two male and one female), and three were Hispanic (zero male and three female).

Design and Materials

As previously mentioned, female participants participated in three EEG recording sessions and male participants participated in a single EEG recording session. In addition, each female participant met with the principal investigator once before their EEG sessions began. During this meeting participants were asked to fill out a consent form, a demographic questionnaire, and a medical history questionnaire (male participants filled out these forms at the beginning of their EEG session). Each female participant was also given a luteinizing hormone (LH) home-use urine test kit and was asked to test their urine once a day, each day, beginning on day eight of their menstrual cycle to identify when ovulation occurred. Participants were asked to notify the principal investigator when ovulation occurred (as indicated with the LH test) or by day 18 of their menstrual cycle if the LH test did not indicate ovulation had occurred. In addition, female participants were asked to notify the principal investigator when menses occurred.

During this initial meeting, each participant's previous three-month menstrual history was used to determine their current menstrual phase status and to assist with

participant grouping. Each participant was placed in either the menses, ovulation, or post-ovulation group where their first EEG would be during their menses, ovulation, or post-ovulation phases. For example, an individual in the ovulation group would have her first EEG recording session during her ovulation phase, her second session during her post-ovulation phase, and her third session during her menses phase while someone in the post-ovulation phase would have her first session during her post-ovulation phase, her second session during her menses phase, and her third session during her ovulation phase. Originally, the three groups were assigned the same number of participants (six each); however, due to unexpected early onset of their menses phase, four participants had to be reassigned to other groups. In addition, another participant was reassigned due to a misunderstanding with ovulation reporting. In the end, seven participants had their first EEG recording session during their menses phase, three participants during their ovulation phase, and eight participants during their post-ovulation phase. After discarding data due to equipment malfunctions, high-error rates, and different sampling rates (as previously discussed), six participants in the menses group, two participants in the ovulation group, and seven participants in the post-ovulation group were used in the final analysis. All three of each of these participants' EEG sessions were used in the final analyses.

Menses recording sessions occurred between days 1 to 5 (M = day 3, SD = 1 day) and each participant's menses phase lasted between 4 to 7 days (M = 5.8 days, SD = 1 day). Ovulation recording sessions occurred between days 9 to 26 (M = day 17, SD = 5 days); ten female participants reported ovulation (as indicated by the LH test) and five reported no ovulation. However, despite whether or not a participant had ovulated, each

participated in an EEG recording session during this time-frame. Post-ovulation recording sessions occurred between days 23 to 32 (M = day 26, SD = 3 days). The overall length of menstrual cycles during the participant's EEG recordings was between 26 to 40 days (M = 30 days, SD = 4 days). All female participants had normal menstrual cycles for the previous three months and none of the changes in their menstrual patterns are believed to be a result from their participation in this study. Early menses onset and lengthened menstrual cycles were believed to be the result of menstrual co-cycling occurring due to new roommates (EEG recording sessions happened to begin during the first week of Fall Semester).

The variations in hormone levels experienced during various phases of menstruation were expected to impact the latency and amplitude of the P300 and N400 components. The menses phase is associated with low levels of estrogen, LH, and progesterone; the ovulation phase is associated with increased levels of estrogen, peak levels of LH, and low levels of progesterone; and the post-ovulation phase is associated with increased levels of estrogen and progesterone and low levels of LH. Thus each female participant served as her own control.

Participants completed a similar visual attention "pop-out" paradigm to the one described by Steffensen et al., (2008). The visual stimuli consisted of three randomly-presented 3X3 matrices with eight right-facing arrows (white figures on black background) and an additional stimulus embedded at random positions in the matrix. The additional stimuli consisted of either another right-facing arrow which served as the "Standard" stimulus, a diamond (target) stimulus which served as the "Relevant" stimulus, or a diamond with lines through it which served as the "Irrelevant" stimulus.

The Relevant and Irrelevant stimuli appeared randomly in any of the nine positions of the 3x3 matrix during each of the EEG sessions. Refer to Figure 3 for visual examples of these three types of stimuli.

Procedure

A brief verbal explanation of the task was given and the experimenters answered any questions. At the beginning of each session (once the sensor net was in place), each participant read a standard set of instructions displayed on the computer screen that described the task they were to perform and sample visual stimuli were presented. The participants were directed to respond, by pressing "0" on a key pad, to any Relevant stimuli and not to respond to Irrelevant or Standard stimuli. Each session consisted of 54 presentations of each of the three matrices (i.e., Relevant, Irrelevant, and Standard stimuli). A fixation dot was presented before each stimulus presentation, varying in length between 1 to 2 sec; this was followed by a blank screen, varying in length of either 1, 1.5, or 2 sec; and finally the stimulus presentation which was displayed for 50 msec. Visual feedback regarding target detection and reaction time (RT) was displayed on the computer screen immediately after each trial. RT was measured from the time of visual stimulus presentation to the time the participant pressed the key. Participants were shown their RT (measured within 1 msec precision) when they responded to the Relevant stimulus and an 'Incorrect' when they responded to the Irrelevant or Standard stimuli.

E-Prime software (Pittsburgh, PA) was used to run the visual attention task and the stimuli were presented on a PC-type computer screen. Visual stimuli were displayed for 50 msec, approximately 61 cm in front of each participant. EEG was recorded with a 64 channel Electrical Geodesics, Inc (EGI) system (Eugene, OR). The sensor net was a

Hydrocel GSN 64 v1.0. The electrode configuration for the EGI sensor net is shown in Figure 1.

Net Station software was used to acquire and analyze the EEG data. Visual evoked potentials (VEPs) were acquired in 1-sec epochs during each visual stimulus presentation; beginning 100 msec prior to and ending 900 msec after each stimulus presentation. The 54 stimulus presentations for each of the three matrices (i.e., Relevant, Irrelevant, and Standard stimuli) at a 10-20 electrode position array (Figure 2; correspond with the green labels on the 64 channel sensor net in Figure 1) were also averaged. Specifically, each participant's EEG session data was filtered using a 1-55 Hz bandpass followed by segmentation coding for each trial. Artifact detection was used to mark bad channels and segments due to eye blinks and eye movement; bad channels were replaced and ocular artifacts were removed. Averaged data was obtained using an adaptive mean method and the reference electrode was adjusted during the off-line analysis. Finally, baseline correction was used beginning at 100 msec before stimulus presentation.

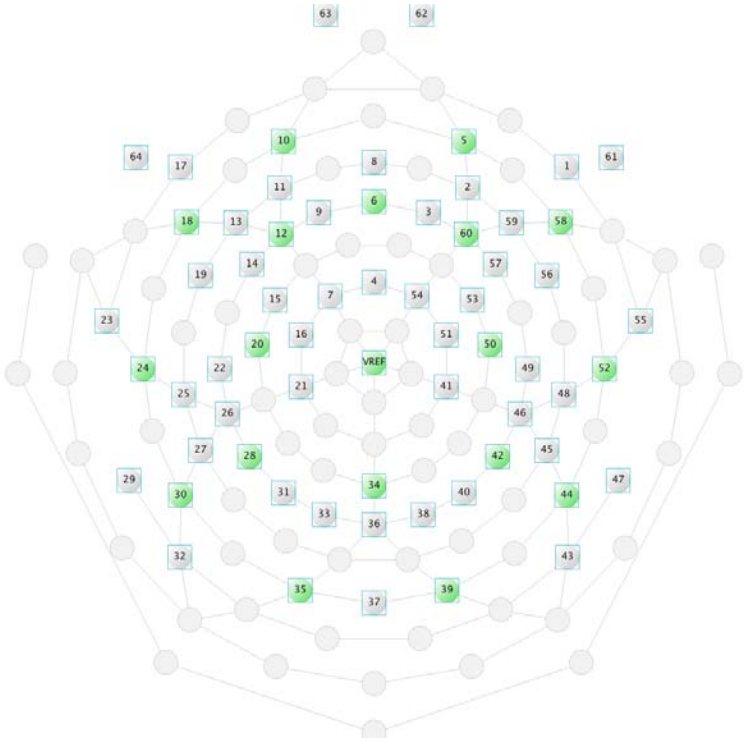

Figure 1. Electrode configuration for 64-channel EEG sensor net.

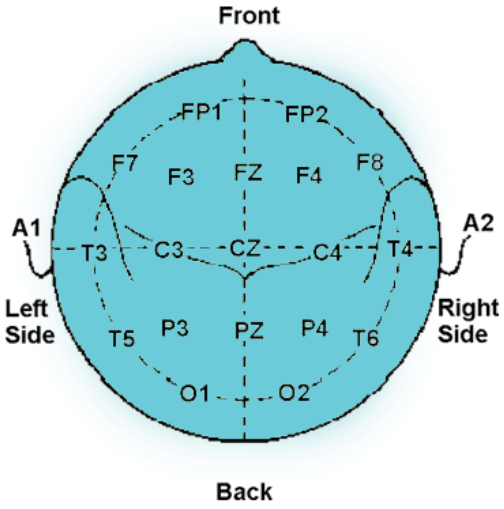

Figure 2. Electrode position array for a 10-20 montage.

The latency and amplitude were measured for each of the peaks of the within-subject averaged VEP components N50, P100, N100, P200, N200, P300, and late-negative (LN). Measures of RT were analyzed with an ANOVA and VEP components were analyzed with a three-way repeated measures MANOVA design for the menstrual phase comparison, with group (menstrual phase), person, and condition (Relevant, Irrelevant, and Standard stimuli) as between-subjects factors and a two-way repeated measures MANOVA design for the gender comparison, with group (gender) and condition (Relevant, Irrelevant, and Standard stimuli) as between-subjects factors. Male participants were compared to female participants (by menstrual phase) in hopes of replicating and extending previous gender differences found by Steffensen et al., (2008).

Results

VEP Late Components are Differentially Modulated by Response Selection

Figure 3 shows a montage of superimposed grand averaged VEPs for one female participant recorded from 19 sites on the standard International 10-20 System in association with the presentation of Relevant, Irrelevant and Standard stimuli. The insets above the montage show the three 3X3 matrices that were randomly presented at 2-4 sec intervals during the 12 min recording session (i.e., Relevant, Irrelevant, and Standard stimuli). One object in the Relevant matrix of right-pointing arrows is a diamond symbol and one object of the Irrelevant matrix is a variation of a diamond and an arrow. Regardless of matrix, these elements are readily distinguished and "pop-out" from the other eight elements of each matrix. The Standard matrix consists of all right-pointing arrows. Subjects were instructed to press a key pad button when the Relevant stimulus was randomly presented, but to not respond when either the Irrelevant or Standard stimuli were presented. VEPs elicited by Relevant, Irrelevant, and Standard stimuli are superimposed at each electrode site. The parietal and occipital electrode sites evinced the most well-defined combination of early (i.e., task-dependent) and late (task-independent) components of the VEP. Negative voltage is plotted downward. F corresponds to frontal, C to central, T to temporal, P to parietal, and O to occipital.

Inspection of the recordings at each electrode location revealed that the VEP waveforms evoked at the parietal and occipital electrodes contained the most well-defined combination of early and late components in association with the Relevant and Irrelevant stimuli. While the early components (i.e., N50, P100, N100, P200 and N200) of the averaged VEP waveforms were relatively unaffected by type of visual stimulus

presented, the late components of the averaged VEP waveforms (P300 and LN) evinced significant amplitude differences across stimulus conditions. Also, note that the P300 for some electrodes on the right side of the head appear greater in amplitude than those on corresponding sites on the left side of the head of this participant. The amplitude of the P300 component of the waveform appeared to be much greater in association with the Relevant stimulus than with Irrelevant and Standard stimuli, in particular at occipital and parietal locations.

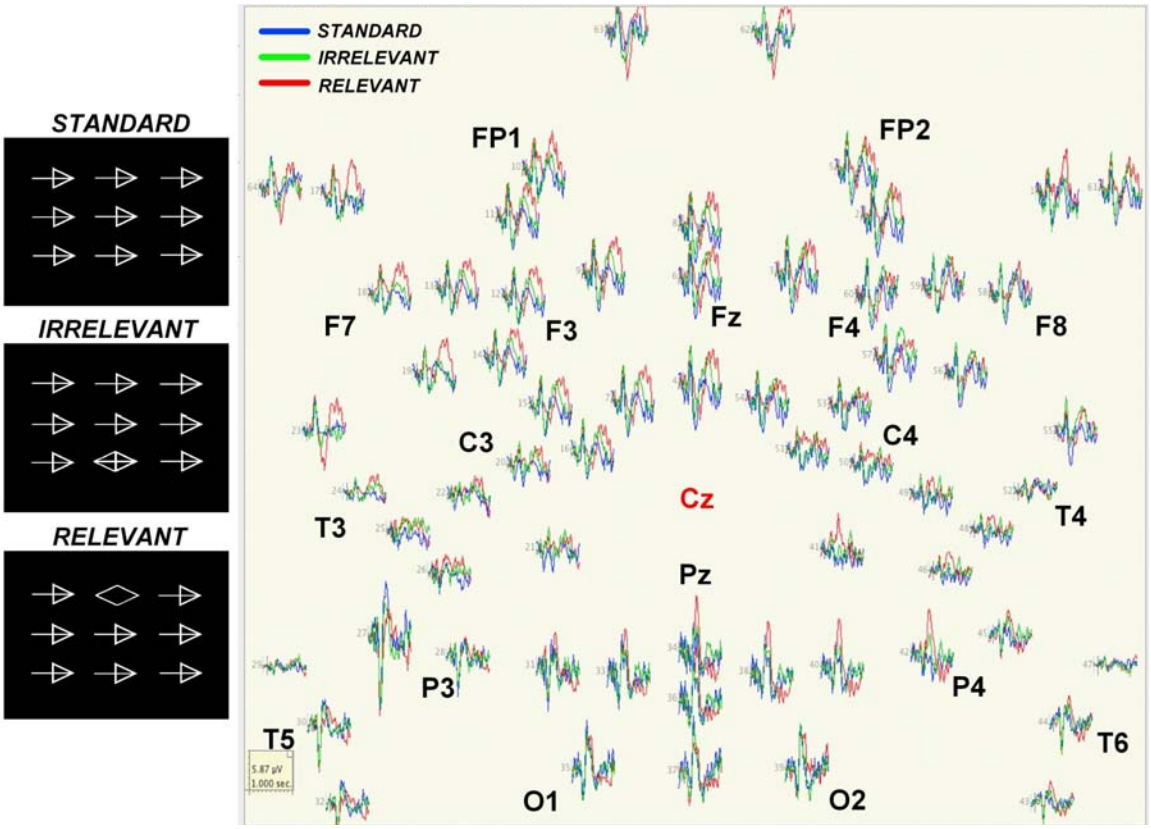

Figure 3. Montage of visual evoked potentials (VEPs) obtained in a representative female participant during an object recognition task.

Grand-averaged VEPs

The effects of response selection on reaction time (RT) and VEPs were studied across phases of the menstrual cycle and in male participants in the object recognition task. Reaction times to the Relevant stimulus were not significantly different in males vs females or between phases of the menstrual cycle ($p = .55$, M male RT = 413 ± 7.7 msec; M menses RT = 431 ± 13.3 msec; M ovulation RT = 422 ± 9.9 msec; and M post-ovulation RT = 404 ± 12.0 msec). Figures 4-7 show grand averaged VEPs, synoptic plots, and topomaps obtained across phases of the menstrual cycle and in male participants.

Figure 4, section A shows the superimposed grand averaged VEPs for the Relevant, Irrelevant, and Standard stimuli recorded from the Pz electrode during the menses phase. The averaged VEP in female participants during their menses phase consisted of multiple components which were identified by their respective positions on the waveform, relative to the time of stimulus presentation (the dashed vertical line represents the time of presentation of the visual stimulus). Seven distinctive alternating positive/negative peaks on the VEP waveform were identified, which occurred at characteristic latencies from the time of stimulus presentation. Early and late peaks of the VEP were identified according to established convention and were labeled N50, P100, N100, P200, N200, and P300, respectively. A late VEP component, termed the late negative (LN), was also identified. Each VEP waveform included the N50, P100, N100, P200, N200, P300 and LN components; however, their latency and amplitude were dependent on stimulus condition. For example, note that the P300 generated in association with participant responding to the Relevant stimulus is much larger than that

obtained in association with Irrelevant and Standard stimuli. The mean RT to the Relevant stimulus for menses participants is also shown on the plot.

The synoptic image plots (Figure 4, section B) show grand averaged VEPs generated at each of the 64 electrode sites in menses participants by Standard (top), Irrelevant (middle) and Relevant (bottom) stimuli. They show color weightings of potentials ranging from strong negative potentials in violet to strong positive potentials in red 100 msec before and 900 msec after the stimulus. Electrodes in the middle of the plot are occipital and parietal leads, while flanking electrodes are temporal and frontal leads. Note that for the Relevant stimulus, at approximately 300 msec, there is a positive red band at occipital and parietal electrodes and a negative blue band at temporal and frontal electrodes that is not apparent with the Standard and Irrelevant stimuli.

Similar to the synoptic plots, the topomaps (Figure 4, section C) show color weightings of potentials recorded at all 64 electrode sites corresponding to respective landmarks on the VEP: Baseline, N100, P300, and LN (40 msec window at -40 msec, 150 msec, 320 msec, and 500 msec). Note that the topomap for the Relevant stimulus differs considerably from the Standard and Irrelevant stimuli evincing strong signals occipitally and frontally. Also, there appears to be an asymmetric distribution of sources with the P300, but not the N100.

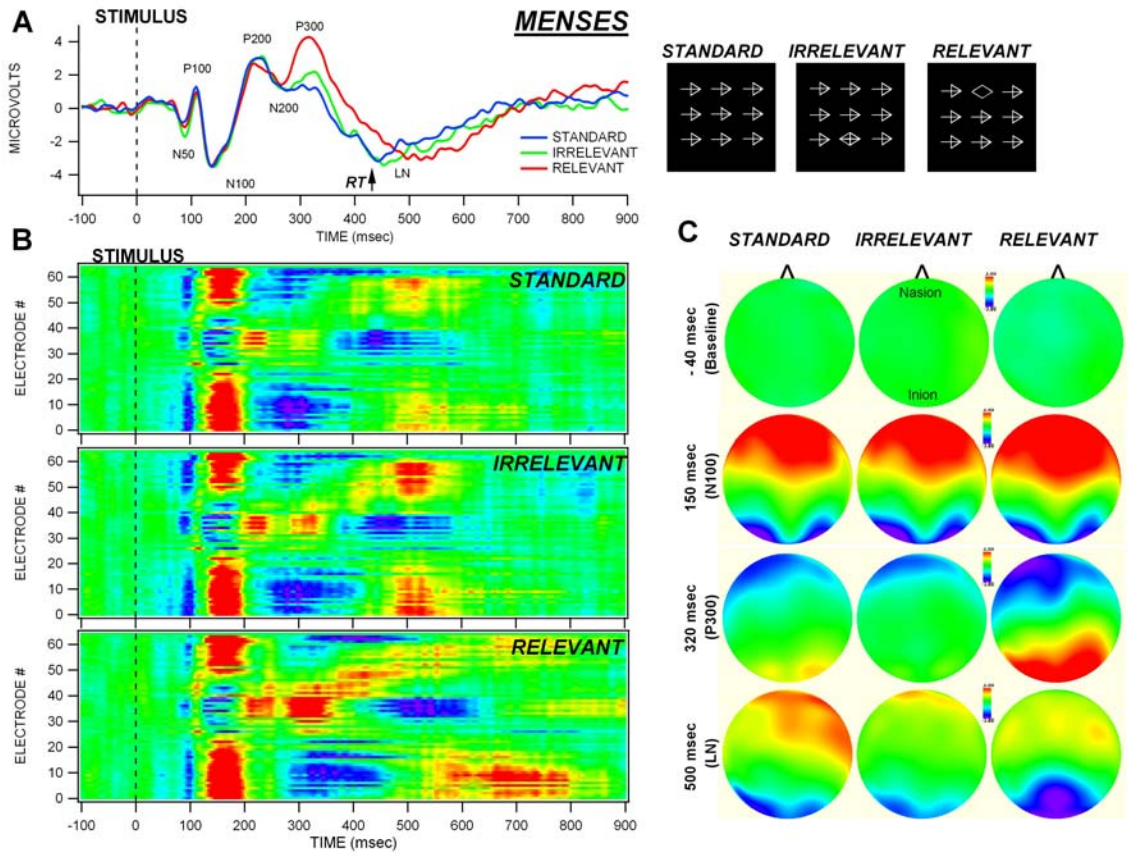

Figure 4. Distribution of visual evoked potentials (VEPs) and differential modulation of event related potentials (ERPs) in female participants in the menses phase of the menstrual cycle.

Figure 5 shows grand-averaged VEPs recorded in female participants during ovulation and are qualitatively similar across stimulus conditions (i.e., Standard, Irrelevant and Relevant) to those of the menses phase. Figure 6 shows grand-averaged VEPs recorded in participants during their post-ovulation phase and are qualitatively similar across stimulus conditions (i.e., Standard, Irrelevant and Relevant) to those of the menses and ovulation phases.

Grand-averaged VEPs recorded in male participants (see Figure 7) were qualitatively similar across stimulus conditions (i.e., Standard, Irrelevant and Relevant) to those of females, albeit some components appeared to be smaller in amplitude.

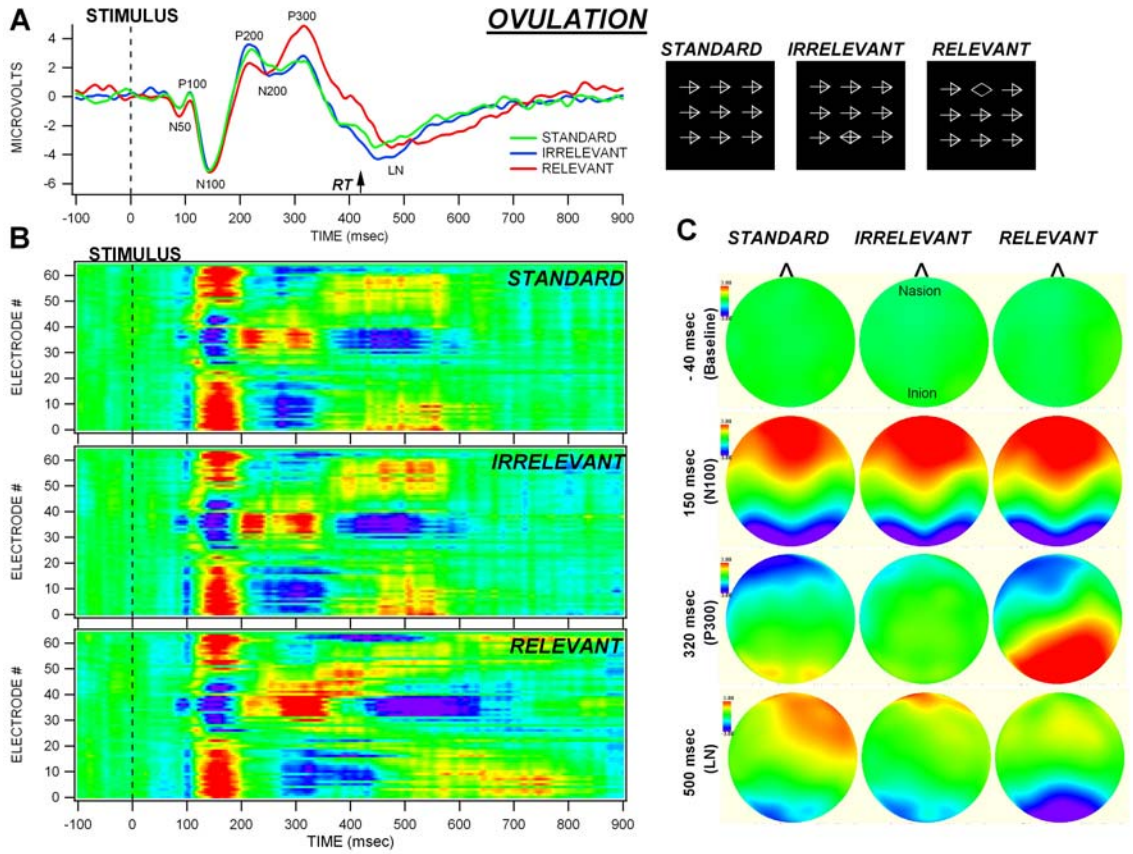

Figure 5. Distribution of visual evoked potentials (VEPs) and differential modulation of event related potentials (ERPs) in female participants in the ovulation phase of the menstrual cycle.

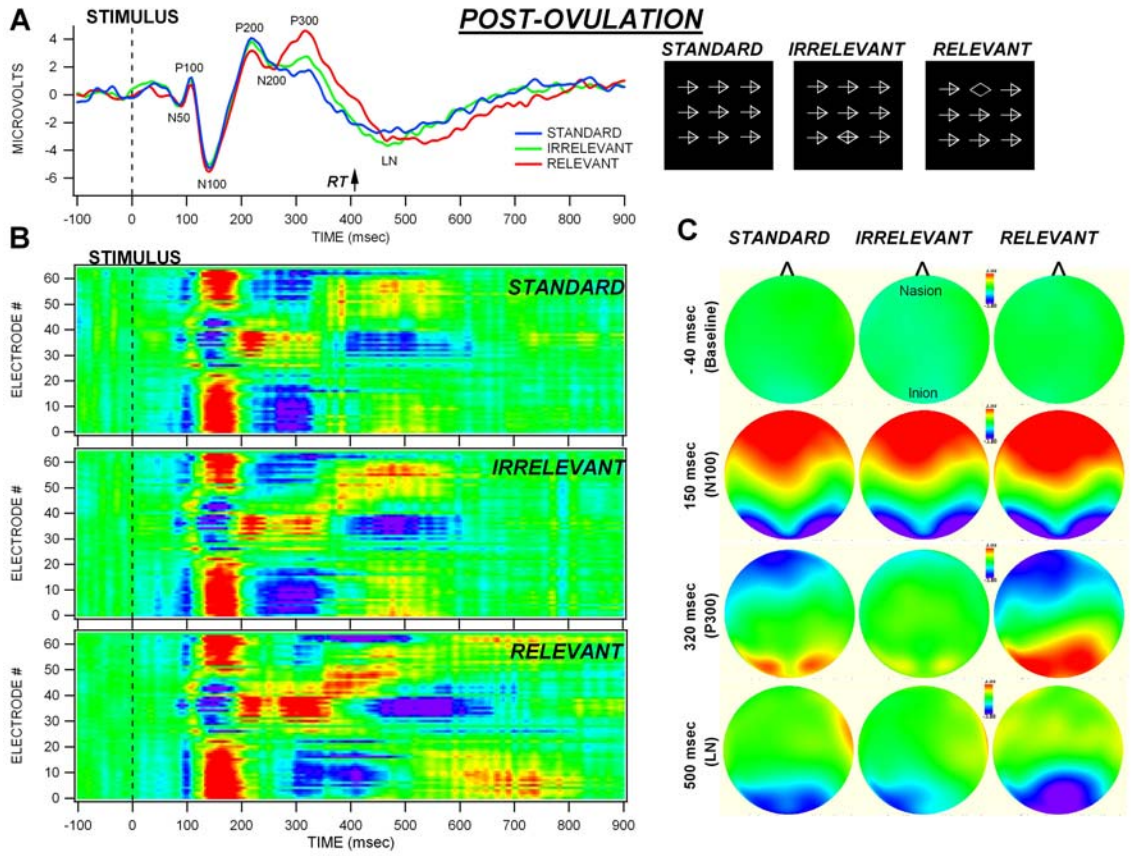

Figure 6. Distribution of visual evoked potentials (VEPs) and differential modulation of event related potentials (ERPs) in female participants in the post-ovulation phase of the menstrual cycle.

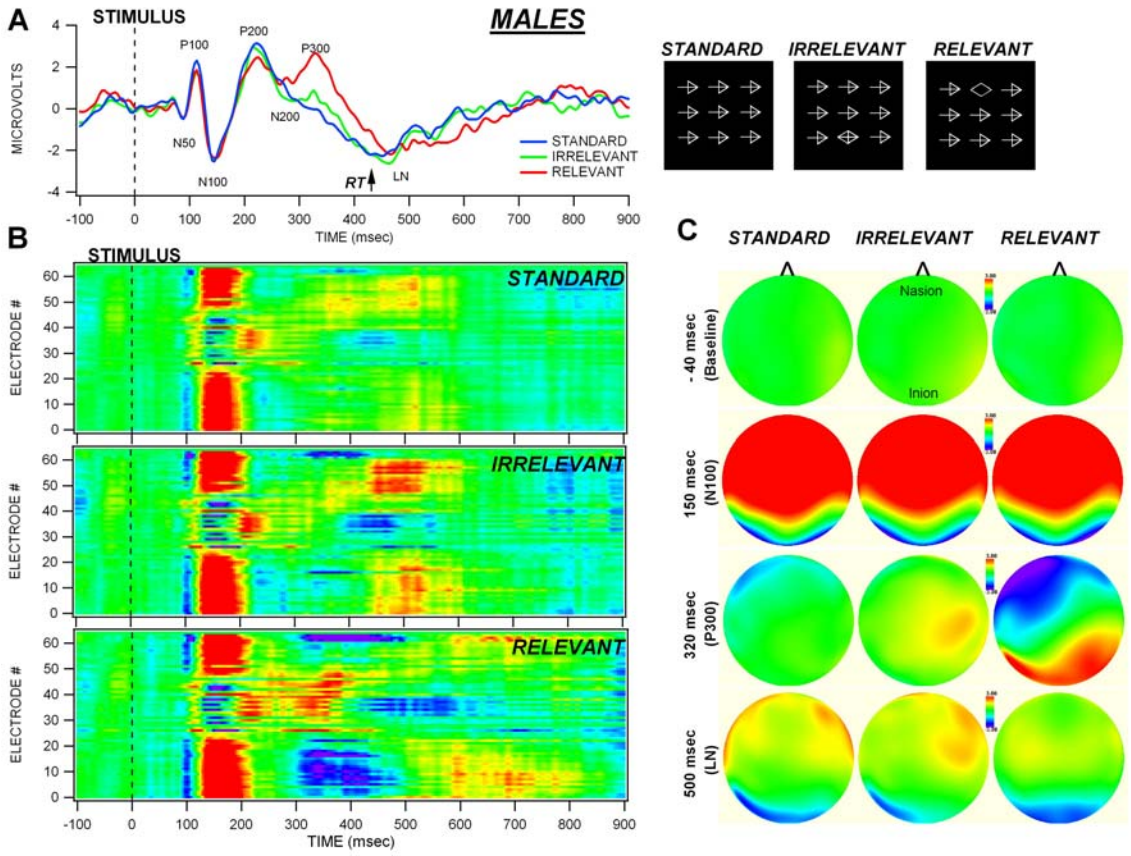

Figure 7. Distribution of visual evoked potentials (VEPs) and differential modulation of event related potentials (ERPs) in male participants.

VEP Comparison Between Female and Male Participants

Figure 8 compares superimposed grand averaged VEPs for the Relevant Stimulus across phases of the menstrual cycle and male participants. The graph in section A shows grand-averaged VEPs in male participants and female participants in their menses, ovulation and post-ovulation phases in association with the Relevant Stimulus. Note that for early VEP components, males look most similar to the menses phase. Also note that for late VEP components the male P300 is considerably smaller in amplitude than any of the phases of the menstrual cycle in females.

The grand-averaged topomaps (Figure 8, section B) show the anatomical distribution of potentials in association with the P300 Relevant stimulus in male participants and female participants across phases of the menstrual cycle. Note that while qualitatively they are similar, there are quantitative differences in the degree of P300 positive signals distributed occipitally.

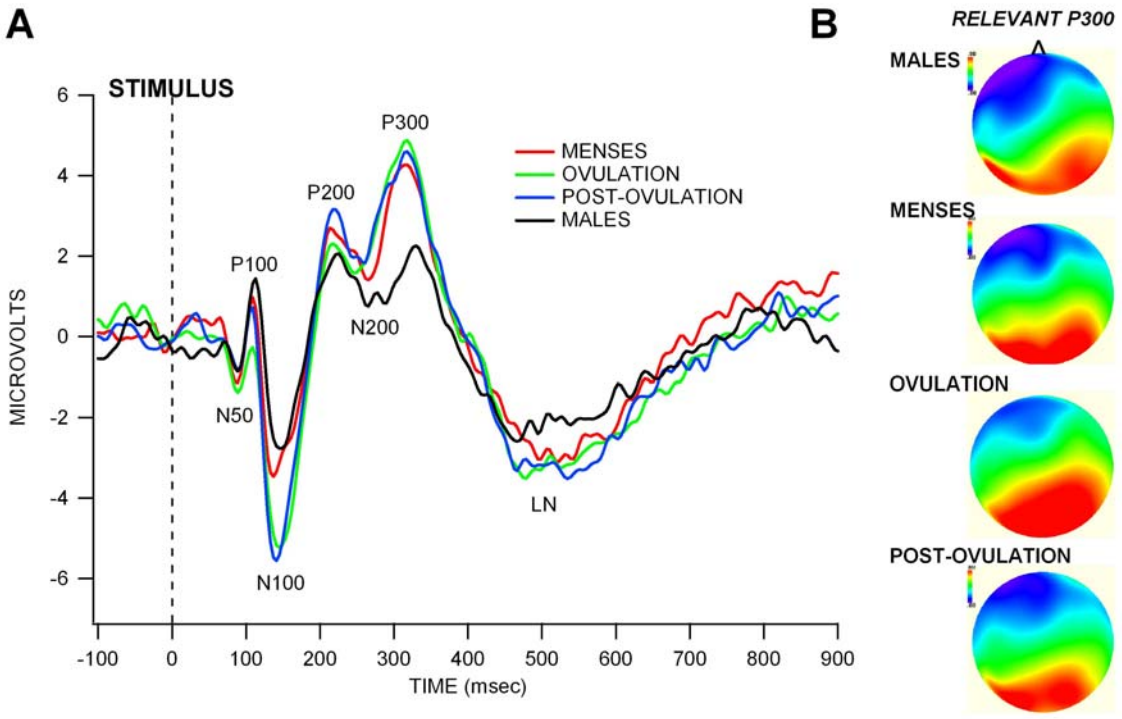

Figure 8. Comparison of visual evoked potentials (VEPs) obtained in male and female participants across the menstrual cycle for the Relevant stimulus.

VEP Latency and Amplitude Measurements

Figure 9 shows the measurements taken within each participant and averaged across participant for each component of the VEP waveform. The section A graph summarizes the effects of stimulus presentation on the latency of discrete components of the VEP. The mean values represent measurements taken from each participants averaged VEP, not from the cumulated averaged VEPs of all participants. The graph in section B summarizes the effects of stimulus presentation on the amplitude of discrete components of the VEP.

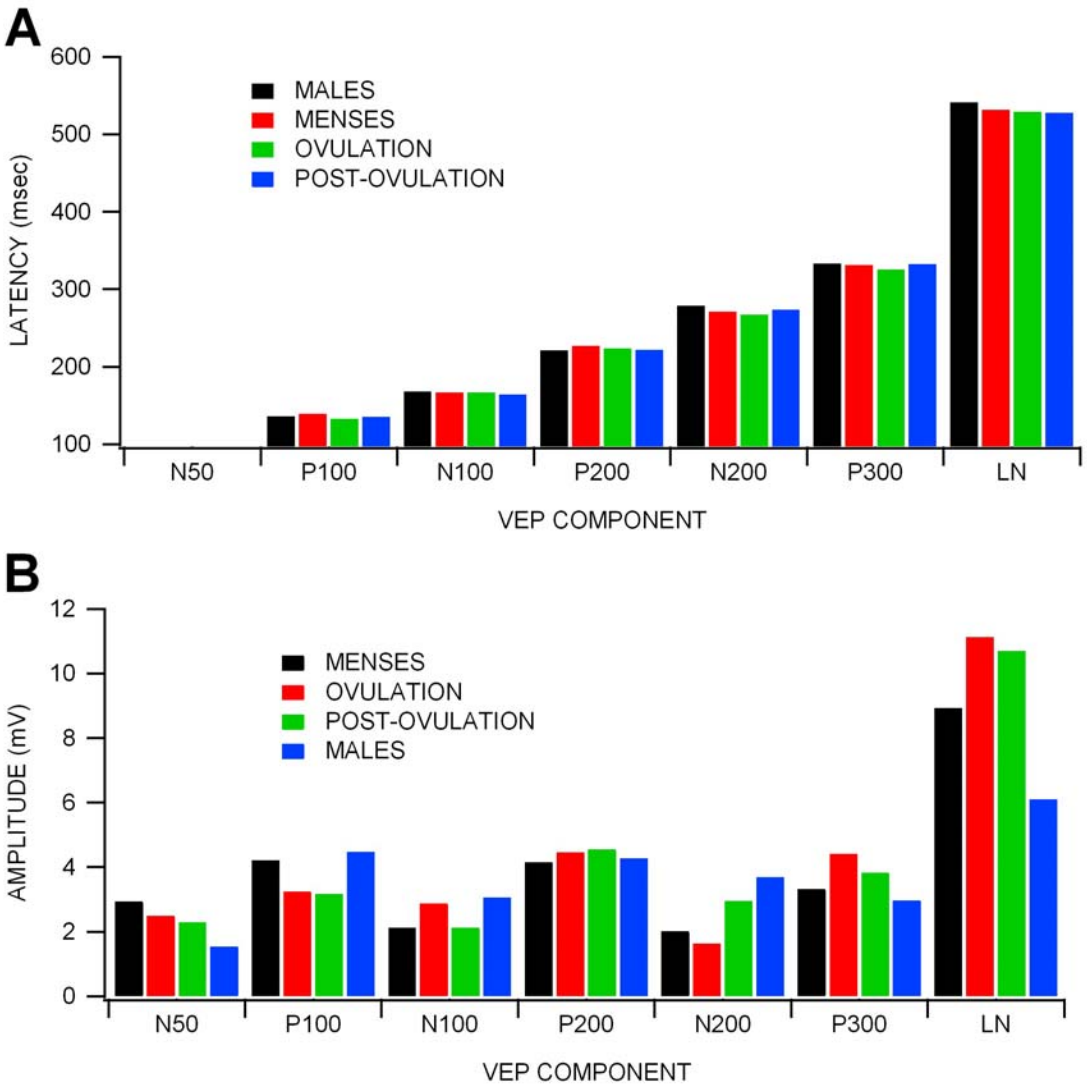

Figure 9. Comparison of discrete visual evoked potential (VEP) component latency and amplitude obtained in male and female participants across the menstrual cycle.

Hemispheric Laterality for P300

As the topomaps in Figures 4-8 showed semi-quantitative signs of P300 laterality, the ratio of 10-20 System electrode sites on the right side of the head compared to the left was measured. Figure 10 shows the ratio of right side electrodes to left side electrodes with an inset of the 10-20 electrode system. All odd numbered electrodes are on the left side of the head while even numbered are on the right. Ratios of complimentary right/left electrodes are shown as percent increase of the right P300 VEP amplitude vs the left. Note that parietal, coronal, and temporal signals are much greater on the right side of the head than on the left.

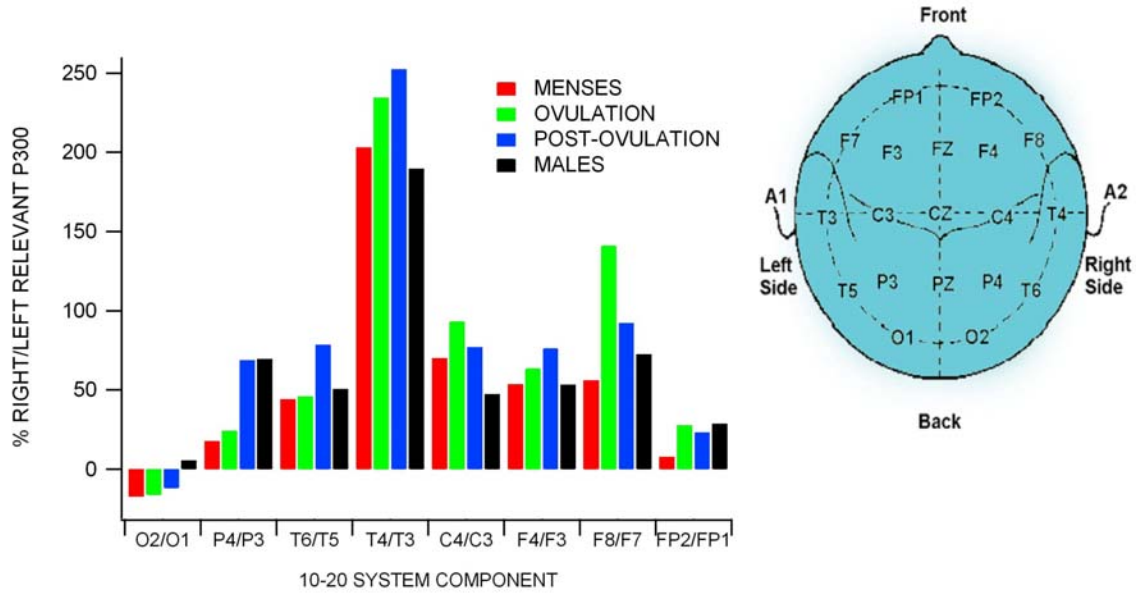

Figure 10. Visual evoked potential (VEP) component P300 laterality.

Multivariate Statistics

Statistical analyses were conducted using SAS statistical software (version 9.1). VEP components were analyzed using a three-way repeated measures MANOVA design for the menstrual phase comparison, with group (menstrual phase), person, and condition (Relevant, Irrelevant, and Standard stimuli) as between-subjects factors and a two-way repeated measures MANOVA design for the gender comparison, with group (gender) and condition (Relevant, Irrelevant, and Standard stimuli) as between-subjects factors. A three-way MANOVA and a two-way MANOVA were run for both amplitude and latency data on each of the seven VEP components (N50, P100, N100, P200, N200, P300, and LN), for a total of twenty-eight MANOVAs (seven three-way repeated measures MANOVA analyses for the amplitude data, seven three-way repeated measures MANOVA analyses for the latency data, seven two-way repeated measures MANOVA analyses for the amplitude data, and seven two-way repeated measures MANOVA analyses for the latency data).

Three-Way MANOVA Summary

Table 1 shows the three-way multivariate summary data for amplitudes by VEP component. Group refers to the comparison of the three menstrual phases (menses, ovulation, and post-ovulation) and was significant for N100 ($p = .0237$), P200 ($p = .0008$), and N200 ($p = .0187$) and the person comparison was significant at every component ($p < .0001$). Condition (COND) refers to the comparison of the three types of stimuli (Relevant, Irrelevant, and Standard) and was significant at six of the seven components (N50 $p = .0275$, P100 $p = .0326$, P100 $p = .0009$, and N200, P300, and LN p values were all $< .0001$). Group by person (G by P) interaction was significant at every

component ($p < .0001$); group by condition (G by P) interaction was significant at six of the seven components (N50 $p = .0426$, P100 $p = .0109$, P200 $p < .0001$, N200 $p = .0191$, P300 $p = .0211$, LN $p = .0144$); and person by condition (P by C) interaction was significant at every component ($p < .0001$).

Table 1. Summary of Three-Way MANOVA Results for Amplitude by VEP Component.

Component	Group (G)	Person (P)	COND (C)	G by P	G by C	P by C
N50	.1023	<.0001**	0.0275**	<.0001**	0.0426**	<.0001**
P100	.3622	<.0001**	0.0326**	<.0001**	0.0109**	<.0001**
N100	0.0237**	<.0001**	.3113	<.0001**	.0566	<.0001**
P200	0.0008**	<.0001**	0.0009**	<.0001**	<.0001**	<.0001**
N200	0.0187**	<.0001**	<.0001**	<.0001**	0.0191**	<.0001**
P300	.0514	<.0001**	<.0001**	<.0001**	0.0211**	<.0001**
LN	.6704	<.0001**	<.0001**	<.0001**	0.0144**	<.0001**

Note. Amplitude data for each of the seven VEP components with menstrual phases as group categories. Quasi F ratios were not calculated for multivariate statistics.

** significant.

Table 2 shows the three-way multivariate summary data for latencies by VEP component. Group was significant for components N100 ($p < .0001$) and P200 ($p = .0271$); person comparison was significant at every component ($p < .0001$); and COND comparison was significant at six of the seven components (P100 $p = .0105$, N100 $p = .0035$, P200 $p = .0005$, and N200, P300, and LN p values were $< .0001$). G by P

interaction was significant at every component ($p < .0001$); G by C interaction was significant at five of the seven components (N50 $p = .0498$, N100 $p = .0047$, P200 $p = .0422$, N200 $p = .0483$, and P300 $p = .0126$); and P by C interaction was also significant at every location ($p < .0001$).

Table 2. Summary of Three-Way MANOVA Results for Latencies by VEP Component.

Component	Group (G)	Person (P)	COND (C)	G by P	G by C	P by C
N50	.3533	<.0001**	.2545	<.0001**	0.0498**	<.0001**
P100	.0711	<.0001**	0.0105**	<.0001**	.1024	<.0001**
N100	<.0001**	<.0001**	0.0035**	<.0001**	0.0047**	<.0001**
P200	0.0271**	<.0001**	0.0005**	<.0001**	0.0422**	<.0001**
N200	.7026	<.0001**	<.0001**	<.0001**	0.0483**	<.0001**
P300	.3365	<.0001**	<.0001**	<.0001**	0.0126**	<.0001**
LN	.2447	<.0001**	<.0001**	<.0001**	.1705	<.0001**

Note. Latency data for each of the seven VEP components with menstrual phases as group categories. Quasi F ratios were not calculated for multivariate statistics.

** significant.

Two-Way MANOVA Summary

Table 3 shows the two-way multivariate summary data for amplitudes by VEP component. In the male vs. menses phase comparison, group refers to the comparison of males to women at each specified menstrual phase and COND refers to the three types of stimuli (Relevant, Irrelevant, and Standard). Group was significant for the N200 component ($p = .0094$); COND was significant for the N200 ($p = .0276$), P300 ($p < .0001$), and LN ($p < .0001$) component; and G by C interaction was significant for the P200 ($p = .0210$), P300 ($p = .0251$), and LN ($p = .0056$) components.

In the male vs. ovulation phase comparison, group was significant for the P100 ($p = .0378$) and N200 ($p = .0401$) components; COND was significant for six of the seven components (P100 $p = .0220$, N100 $p = .0242$, P200 $p = .0010$, N200 $p = .0150$, P300 $p < .0001$, and LN $p < .0001$); and G by C interaction was significant for five of the seven components (N50 $p = .0049$, P200 $p = .0121$, N200 $p = .0056$, P300 $p = .0458$, and LN $p = .0016$).

In the male vs. post-ovulation phase comparison, group was significant for the N200 component ($p = .0170$); COND was significant for the P200 ($p = .0225$), N200 ($p = .0047$), P300 ($p < .0001$), and LN ($p < .0001$) components; and G by C interaction was significant for the P100 ($p = .0438$) and LN components ($p = .0152$).

Table 3. Summary of Two-Way MANOVA Amplitude Results by VEP Component.

	Male vs Menses			Male vs Ovulation			Male vs Post Ovulation		
Component	Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C
N50	.1726	.7512	.3632	.1747	.7110	0.0049**	.2767	.1840	.1615
P100	.4584	.6990	.1274	0.0378**	0.0220**	.1222	.0704	.3522	0.0438**
N100	.4108	.1780	.5267	.5526	0.0242**	.1161	.8815	.1953	.4817
P200	.1922	.3296	0.0210**	.2994	0.0010**	0.0121**	.1673	0.0225**	.2436
N200	0.0094**	0.0276**	.0889	0.0401**	0.0150**	0.0056**	0.0170**	0.0047**	.1297
P300	.0838	<.0001**	0.0251**	.2191	<.0001**	0.0458**	.5124	<.0001**	.4850
LN	.8280	<.0001**	0.0056**	.1536	<.0001**	0.0016**	.8249	<.0001**	0.0152**

Note. Amplitude data for each of the seven VEP components with gender as group categories.

** significant.

Table 4 shows the two-way multivariate summary data for latencies by VEP component. In the male vs. menses phase comparison, group was not significant for any of the components; COND was significant for the N100 ($p = .0400$), P200 ($p = .0147$), N200 ($p = .0001$), P300 ($p = .0125$) and LN ($p < .0001$) components; and G by C interaction was significant for the N200 component ($p = .0107$).

In the male vs. ovulation phase comparison, group was not significant for any component; COND was significant for components P200 ($p = .0158$), N200 (.0092), P300 ($p = .0203$), and LN ($p < .0001$); and G by C interaction was significant for the N100 component ($p = .0252$).

In the male vs. post-ovulation phase comparison, group was not significant for any of the components; COND was significant for components P100 ($p = .0118$), P200 ($p = .0462$), N200 ($p < .0001$), P300 ($p < .0001$), and LN ($p < .0001$); and G by C interaction was significant for the P100 ($p = .0137$), N100 ($p = .0250$), and N200 ($p = .0447$) components.

Table 4. Summary of Two-Way MANOVA Latencies Results by VEP Component.

	Male vs Menses			Male vs Ovulation			Male vs Post Ovulation		
Component	Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C
N50	.0857	.1311	.3951	.1924	.8440	.0806	.5993	.2357	.0752
P100	.3979	.2924	.4932	.2187	.3529	.3258	.3198	0.0118**	0.0137**
N100	.0828	0.0400**	.5964	.3159	.3375	0.0252**	.7385	.3671	0.0250**
P200	.5208	0.0147**	.0518	.3284	0.0158**	.5828	.7138	0.0462**	.0656
N200	.4021	0.0001**	0.0107**	.3160	0.0092**	.5334	.2580	<.0001**	0.0447**
P300	.6633	0.0125**	.4295	.1346	0.0203**	.1002	.2494	<.0001**	.1090
LN	.5598	<.0001**	.2297	.4044	<.0001**	.0865	.7421	<.0001**	.3684

Note. Latency data for each of the seven VEP components with gender as group categories.

** significant.

VEP Components in Greater Detail for the Three-Way Model

Amplitude data for components P200 and N200 were looked at in greater detail due to significance being reached across the model. A pseudo F test (Hicks, 1973) was used to calculate the F ratios and probability ratios for condition due to an incorrect error term used within the three-way MANOVA model. Table 5 shows the menstrual phase comparison for P200 amplitude by location. G by P interaction was significant ($p < .0001$) at every location; menstrual phase comparison (group) was significant at locations F3 through Fz; person was significant at locations O1 through Pz and T3 through T6; G by C and P by C interactions varied in significance by location (refer to Table 5 for specific p-values).

Table 6 shows the results for N200 amplitude comparison across menstrual phase. Person was significant ($p < .0001$) at every location; G by P interaction was also significant at every location (F8 $p = .0002$; all other locations $p < .0001$); group was significant for locations F3 ($p = .0282$), F7 ($p = .0143$), Fp2 ($p = .0360$), and Fz ($p = .0244$); COND was significant for location O2 ($p = .0165$); G by C interaction was significant at locations O2 ($p = .0317$) and T6 ($p = .0339$); and P by C interactions varied in significance by location (refer to Table 6 for specific p-values).

Table 5. Summary of Three-Way MANOVA Results for P200 Amplitudes by Location.

Location		Group (G)	Person (P)	COND (C)	G by P	G by C	P by C
C3	p value	.0847	.0848	.7623	<.0001**	.1881	.4278
	Percent Variance	8.44%	40.01%	0.08%	43.78%	0.53%	2.46%
C4	p value	.4823	.1012	.5540	<.0001**	.0810	.1048
	Percent Variance	2.19%	35.88%	0.68%	41.02%	1.67%	7.90%
F3	p value	0.0001**	.8012	.7883	<.0001**	0.0274**	.2738
	Percent Variance	36.06%	12.58%	0.19%	38.77%	1.44%	4.11%
F4	p value	0.0002**	.7731	.8729	<.0001**	0.0019**	0.0139**
	Percent Variance	30.21%	11.93%	0.28%	35.03%	3.35%	9.60%
F7	p value	<.0001**	.8131	.6070	<.0001**	.0810	.4315
	Percent Variance	42.85%	10.75%	0.34%	33.85%	1.14%	3.80%
F8	p value	0.0004**	.8348	.8709	<.0001**	0.0221**	.1001
	Percent Variance	27.99%	11.35%	0.22%	37.25%	2.62%	8.80%
Fp1	p value	0.019**	.7972	.8774	<.0001**	0.0024**	.2773
	Percent Variance	15.38%	15.37%	0.27%	47.03%	3.81%	6.79%
Fp2	p value	0.0214**	.6317	.3749	<.0001**	.4721	.3661
	Percent Variance	16.20%	21.34%	0.33%	51.29%	0.43%	3.70%
Fz	p value	0.0027**	.9069	.9782	<.0001**	0.0004**	.1702
	Percent Variance	23.63%	11.49%	0.05%	45.05%	4.02%	6.34%
O1	p value	.4392	<.0001**	.0896	<.0001**	.2972	0.0001**
	Percent Variance	1.21%	75.33%	0.41%	19.95%	0.10%	1.85%
O2	p value	.1564	<.0001**	.4542	<.0001**	.0381	.1101
	Percent Variance	2.13%	80.20%	0.14%	15.07%	0.25%	0.94%
P3	p value	.7831	<.0001**	.6998	<.0001**	.0533	.3459
	Percent Variance	0.27%	82.64%	0.03%	15.44%	0.16%	0.52%
P4	p value	.8467	<.0001**	.2719	<.0001**	.4575	.5208
	Percent Variance	0.23%	74.00%	0.25%	19.60%	0.25%	1.85%
Pz	p value	.8618	<.0001**	.8178	<.0001**	0.0104**	.1355
	Percent Variance	0.27%	72.12%	0.04%	25.14%	0.32%	0.87%
T3	p value	.1417	.2739	.7077	<.0001**	.1625	.9695
	Percent Variance	7.27%	31.29%	0.20%	48.54%	1.12%	2.38%
T4	p value	.9022	<.0001**	.2786	<.0001**	.2843	.4140
	Percent Variance	0.16%	62.39%	0.88%	21.86%	0.84%	4.81%
T5	p value	.9950	0.0002**	.2276	<.0001**	.2611	0.0206**
	Percent Variance	0.01%	68.23%	0.19%	28.80%	0.13%	1.28%
T6	p value	.7969	0.0226**	.5845	<.0001**	.2654	.7788
	Percent Variance	0.71%	52.51%	0.06%	43.39%	0.22%	0.86%

Note. Amplitude P200 data for each of the eighteen locations with menstrual phase as group categories.

Percent variance calculated using the R-Squared method.

** significant.

Table 6. Summary of Three-Way MANOVA Results for N200 Amplitudes by Location.

Location		Group (G)	Person (P)	COND (C)	G by P	G by C	P by C
C3	p value	.3922	0.0073**	.4488	<.0001**	.6378	0.0024**
	Percent Variance	2.54%	54.12%	0.18%	36.80%	0.13%	3.41%
C4	p value	.2928	<.0001**	.6339	<.0001**	.9101	.1028
	Percent Variance	1.62%	67.22%	0.10%	17.71%	0.13%	5.63%
F3	p value	0.0282**	<.0001**	.6997	<.0001**	.3081	0.0015**
	Percent Variance	4.56%	68.60%	0.17%	15.69%	0.41%	5.93%
F4	p value	.1766	<.0001**	.7445	<.0001**	.4442	0.0016**
	Percent Variance	1.73%	73.66%	0.13%	13.13%	0.33%	6.15%
F7	p value	0.0143**	<.0001**	.8508	<.0001**	.4722	0.0002**
	Percent Variance	7.11%	59.47%	0.09%	20.05%	0.33%	7.79%
F8	p value	.0620	<.0001**	.5308	0.0002**	.5254	0.0069**
	Percent Variance	2.63%	68.23%	0.37%	11.99%	0.45%	8.49%
Fp1	p value	.1517	<.0001**	.0702	<.0001**	.4589	.1236
	Percent Variance	2.07%	70.55%	1.35%	14.38%	0.43%	4.69%
Fp2	p value	0.036**	<.0001**	.6049	<.0001**	.6884	0.0182**
	Percent Variance	5.16%	67.06%	0.12%	19.25%	0.17%	4.05%
Fz	p value	0.0244**	<.0001**	.4223	<.0001**	.8039	0.0007**
	Percent Variance	4.53%	70.39%	0.29%	14.92%	0.12%	5.61%
O1	p value	.5417	0.0001**	.0989	<.0001**	.0884	.1574
	Percent Variance	0.94%	54.40%	3.69%	21.07%	1.65%	7.41%
O2	p value	.2105	0.0002**	0.0168**	<.0001**	0.0317**	<.0001**
	Percent Variance	2.65%	53.98%	5.76%	22.53%	0.96%	9.38%
P3	p value	.7640	0.0031**	.4645	<.0001**	.1985	.0672
	Percent Variance	0.61%	52.90%	0.51%	31.50%	0.84%	6.06%
P4	p value	.0759	<.0001**	.1667	<.0001**	.1216	0.009**
	Percent Variance	2.88%	63.87%	1.90%	14.23%	1.07%	8.24%
Pz	p value	.0630	0.0026**	.1202	<.0001**	.1026	.0603
	Percent Variance	5.90%	46.54%	2.67%	27.02%	1.32%	7.43%
T3	p value	.6538	0.0202**	.7224	<.0001**	.7105	0.0085**
	Percent Variance	1.18%	47.35%	0.12%	38.34%	0.24%	6.56%
T4	p value	.0882	<.0001**	.7104	<.0001**	.5774	.1208
	Percent Variance	3.61%	56.71%	0.17%	19.04%	0.60%	8.33%
T5	p value	.8988	0.0005**	.5382	<.0001**	.6447	.3667
	Percent Variance	0.21%	57.75%	0.19%	26.97%	0.42%	5.15%
T6	p value	.5172	<.0001**	.1932	<.0001**	0.0339**	0.0179**
	Percent Variance	0.97%	63.65%	1.82%	20.11%	1.24%	6.00%

Note. Amplitude N200 data for each of the eighteen locations with menstrual phase as group categories.

Percent variance calculated using the R-Squared method.

** significant.

Latency data for components N100 and P200 were looked at in greater detail also due to significance being reached across the model. Table 7 shows the results of N100 latencies across locations. Group was significant for locations C3 through Fz (C3 $p = .0488$, C4 $p = .0098$ and F3, F4, F7, F8, Fp1, Fp2, and Fz $p < .0001$), T3 ($p < .0001$), and T4 ($p = .0003$); person was significant for all locations except Fz and T5 (significance varied by location, refer to Table 7 for specific values); G by P interactions were significant at all locations except F7 (p-values varied from .0007 to <.0001); there was only one significant location (O1 $p = .0315$) for G by C interaction; and there were no significant P by C interactions at any of the locations.

Table 8 shows the results of P200 latencies; group was significant for locations F3 through Fz (p-values varied from .0172 to < .0001) and location P4 (.0447); person was significant for ten of the eighteen locations (significance varied by location, refer to Table 8 for specific values); G by P interaction was significant at twelve of the eighteen locations (refer to Table 8); P by C interaction was significant for locations C3 ($p = .0038$), F3 ($p = .0266$), F4 ($p = .0266$), F7 ($p = .0423$), and T6 ($p = .0249$); and G by C interaction was significant at only one location (T6 $p = .0128$).

Table 7. Summary of Three-Way MANOVA Results for N100 Latencies by Location.

Location		Group (G)	Person (P)	COND (C)	G by P	G by C	P by C
C3	p value	0.0488**	0.0145**	.6100	<.0001**	.6716	.9133
	Percent Variance	8.24%	44.91%	0.06%	34.25%	0.39%	2.88%
C4	p value	0.0098**	0.0185**	.3899	<.0001**	.1055	.6304
	Percent Variance	11.06%	35.49%	1.33%	28.27%	2.16%	6.65%
F3	p value	<.0001**	0.0273**	.4329	0.0004**	.3728	.8390
	Percent Variance	37.00%	22.85%	0.85%	19.58%	1.07%	4.88%
F4	p value	<.0001**	0.0268**	.4393	0.0005**	.0892	.5590
	Percent Variance	34.24%	22.81%	1.12%	19.48%	2.09%	6.48%
F7	p value	<.0001**	0.0015**	.1760	.1017	.1595	.4319
	Percent Variance	54.26%	15.89%	2.37%	8.57%	1.41%	6.01%
F8	p value	<.0001**	0.0409**	.0787	0.0001**	.3889	.2352
	Percent Variance	32.72%	21.80%	3.11%	20.25%	0.98%	8.14%
Fp1	p value	<.0001**	0.003**	.4678	0.0004**	.2747	.7354
	Percent Variance	33.34%	29.91%	0.56%	17.72%	1.16%	4.95%
Fp2	p value	<.0001**	0.0007**	.2188	<.0001**	.2318	.0733
	Percent Variance	22.49%	37.33%	1.56%	17.98%	1.12%	8.61%
Fz	p value	<.0001**	.0869	.1888	<.0001**	.2037	.2302
	Percent Variance	40.74%	23.60%	0.85%	25.98%	0.56%	3.19%
O1	p value	.0903	0.0093**	.7913	<.0001**	0.0315**	.3955
	Percent Variance	5.98%	45.09%	0.25%	31.90%	1.97%	5.19%
O2	p value	.3601	0.0014**	.2200	<.0001**	.8607	.7913
	Percent Variance	2.13%	52.71%	0.32%	28.17%	0.28%	4.48%
P3	p value	.2888	0.0169**	.2841	<.0001**	.4706	.5704
	Percent Variance	3.40%	46.79%	0.61%	36.65%	0.53%	3.82%
P4	p value	.5728	0.0013**	.6981	<.0001**	.3337	.7699
	Percent Variance	1.24%	57.81%	0.10%	30.61%	0.58%	2.69%
Pz	p value	.6773	0.0012**	.6567	<.0001**	.1615	.2916
	Percent Variance	0.84%	56.86%	0.23%	29.67%	0.88%	4.28%
T3	p value	<.0001**	0.0103**	.2515	<.0001**	.3434	.1838
	Percent Variance	24.74%	32.18%	1.05%	23.16%	0.89%	7.16%
T4	p value	0.0003**	0.0076**	.3069	0.0007**	.2653	.4356
	Percent Variance	17.53%	32.41%	1.45%	22.20%	1.57%	8.51%
T5	p value	.3800	.0600	.7738	<.0001**	.1065	.5728
	Percent Variance	2.92%	40.50%	0.19%	40.86%	1.38%	4.49%
T6	p value	.8763	0.0154**	.7934	<.0001**	.4149	.4569
	Percent Variance	0.32%	43.72%	0.13%	33.68%	1.00%	7.16%

Note. Latency N100 data for each of the eighteen locations with menstrual phase as group categories.

Percent variance calculated using the R-Squared method.

** significant.

Table 8. Summary of Three-Way MANOVA Results for P200 Latencies by Location.

Location		Group (G)	Person (P)	COND (C)	G by P	G by C	P by C
C3	p value	0.0007**	0.0327**	.6594	0.0110**	.0872	0.0038**
	Percent Variance	13.23%	22.08%	1.03%	19.60%	2.92%	22.06%
C4	p value	.0825	.1337	.1846	0.0010**	.3832	.7852
	Percent Variance	6.07%	25.27%	3.07%	31.13%	1.80%	8.98%
F3	p value	<.0001**	.1085	.0767	.0537	.1672	0.0266**
	Percent Variance	16.81%	15.11%	7.23%	17.60%	2.55%	19.49%
F4	p value	0.0002**	.2592	.2918	.0604	.8123	0.0266**
	Percent Variance	16.75%	13.27%	1.57%	20.17%	0.70%	22.76%
F7	p value	<.0001**	.1502	.1088	0.0055**	.5478	0.0423**
	Percent Variance	23.80%	16.39%	2.97%	20.87%	1.04%	16.16%
F8	p value	0.0172**	.0566	.2162	.2070	.2983	.1648
	Percent Variance	6.39%	19.05%	3.58%	18.96%	2.64%	19.95%
Fp1	p value	0.0006**	0.0128**	.1854	0.047**	.6664	.3695
	Percent Variance	14.01%	26.70%	1.83%	19.94%	1.00%	12.97%
Fp2	p value	0.0007**	0.0114**	.2875	0.0005**	.9721	.1840
	Percent Variance	15.92%	32.06%	0.67%	23.47%	0.15%	11.05%
Fz	p value	<.0001**	.2200	.0850	.1128	.5848	.3630
	Percent Variance	24.56%	12.69%	4.58%	18.20%	1.27%	13.80%
O1	p value	.9038	0.0042**	.2656	.0754	.8165	.8437
	Percent Variance	0.16%	36.48%	0.62%	22.76%	0.80%	10.19%
O2	p value	.8133	0.0002**	.3166	0.0009**	.4883	.0622
	Percent Variance	0.30%	50.02%	1.10%	20.21%	0.94%	12.28%
P3	p value	.2210	0.0143**	.4026	0.0022**	.2661	.4362
	Percent Variance	2.99%	34.57%	1.33%	26.29%	2.06%	11.22%
P4	p value	0.0447**	<.0001**	.0990	0.0033**	.1125	.1962
	Percent Variance	3.48%	57.00%	4.20%	13.98%	1.67%	7.76%
Pz	p value	.0585	0.0003**	.5195	.1331	.3863	.8501
	Percent Variance	4.03%	41.07%	0.92%	17.93%	1.91%	8.82%
T3	p value	.2441	.3156	.0906	<.0001**	.5611	.3981
	Percent Variance	3.82%	22.01%	3.78%	36.09%	1.16%	11.59%
T4	p value	.1432	0.0005**	.0875	0.0051**	.8959	.0800
	Percent Variance	2.96%	43.21%	2.15%	19.86%	0.34%	13.77%
T5	p value	.3266	.1271	.3662	<.0001**	.5799	.0534
	Percent Variance	2.82%	27.91%	1.05%	33.90%	0.94%	15.14%
T6	p value	.6785	0.0001**	.1356	0.0001**	0.0128**	0.0249**
	Percent Variance	0.53%	48.28%	5.76%	19.03%	3.03%	11.24%

Note. Latency P200 data for each of the eighteen locations with menstrual phase as group categories.

Percent variance calculated using the R-Squared method.

** significant.

VEP Components in Greater Detail for the Two-Way Model

Component N200 amplitude data was looked at in greater detail within the two-way model due to its high levels of significance at the multivariate level (significance was reached across the model for the males vs ovulation comparison and at two of the three levels for males va menses and males vs post-ovulation comparisons). In addition, P300 amplitudes and LN amplitudes were also reviewed due to their levels of significance.

Table 9 shows the results of N200 amplitude data for each of the male vs. menstrual phase comparison by location. For the males vs menses phase, significance was reached with group for locations C3 ($p = .0153$), F3 ($p = .0358$), F7 ($p = .0080$), P3 ($p = .0446$), and Pz ($p = .0185$) and COND for locations O1 ($p = .0053$), O2 ($p = .0005$), and P4 ($p = .0409$). There were no significant G by C interactions for this group comparison. For males vs the ovulation phase, group was significant at locations C3 ($p = .0131$), P3 ($p = .0039$), Pz ($p = .0305$), and T3 ($p = .0400$); COND was significant at locations O1 ($p = .0009$), O2 ($p < .0001$), P4 ($p = .0015$), Pz ($p = .0070$), and T6 ($p = .0027$); and G by C was significant at F7 ($p = .0440$) and Fp1 ($p = .0036$). For the males vs post-ovulation phase, group was not significant at any location; COND was significant at locations O1 ($p < .0001$), O2 ($p < .0001$), P4 ($p = .0293$), T5 ($p = .0202$), and T6 ($p = .0076$); and there was one significant G by C interaction at location Fp1 ($p = .0264$).

Table 9. Summary of Two-Way MANOVA Results for N200 Amplitude by Location.

		Male vs Menses			Male vs Ovulation			Male vs Post Ovulation		
Location:		Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C
C3	p value	0.0153**	.0941	.9629	0.0131**	.4325	.4847	.2800	.3071	.7563
	Percent Variance	16.85%	0.75%	0.01%	17.23%	0.31%	0.27%	3.71%	0.30%	0.07%
C4	p value	.1778	.3565	.6644	.1749	.1799	.7296	.6349	.5044	.6138
	Percent Variance	5.50%	0.38%	0.15%	5.37%	0.80%	0.14%	0.71%	0.23%	0.16%
F3	p value	0.0358**	.4858	.3851	.2149	.9229	.0835	.4368	.3292	.3697
	Percent Variance	12.64%	0.28%	0.37%	4.40%	0.04%	1.32%	1.85%	0.44%	0.39%
F4	p value	.1111	.2471	.6076	.2660	.9554	.5452	.5421	.5304	.9815
	Percent Variance	7.60%	0.50%	0.18%	3.68%	0.02%	0.27%	1.16%	0.22%	0.01%
F7	p value	0.0080**	.0981	.4351	.1364	.4779	0.0440**	.2951	.3097	.2154
	Percent Variance	18.94%	1.00%	0.35%	6.29%	0.36%	1.60%	3.26%	0.51%	0.67%
F8	p value	.0636	.4225	.8322	.1460	.8621	.3860	.4004	.6026	.7070
	Percent Variance	10.05%	0.34%	0.07%	6.20%	0.07%	0.43%	2.13%	0.22%	0.15%
Fp1	p value	.2306	.3510	.0662	.4448	.4359	0.0036**	.8357	.8463	0.0264**
	Percent Variance	4.29%	0.41%	1.09%	1.64%	0.45%	3.29%	0.13%	0.07%	1.57%
Fp2	p value	.1582	.4828	.5302	.3102	.6198	.1374	.8981	.2376	.8116
	Percent Variance	6.17%	0.21%	0.18%	3.16%	0.17%	0.71%	0.05%	0.39%	0.06%
Fz	p value	.1381	.6860	.5664	.6214	.9343	.4995	.9794	.4807	.4130
	Percent Variance	6.62%	0.14%	0.21%	0.71%	0.04%	0.38%	0.00%	0.23%	0.28%
O1	p value	.1664	0.0053**	.4955	.3762	0.0009**	.1703	.3964	<.0001**	.7246
	Percent Variance	5.71%	1.97%	0.24%	2.22%	3.71%	0.86%	2.23%	2.89%	0.09%
O2	p value	.2251	0.0005**	.7578	.2306	<.0001**	.4929	.8493	<.0001**	.3125
	Percent Variance	4.40%	2.84%	0.09%	4.07%	5.66%	0.28%	0.10%	6.22%	0.50%
P3	p value	0.0446**	.6815	.8711	0.0039**	.6106	.1536	.1000	.9640	.7292
	Percent Variance	10.47%	0.27%	0.10%	17.41%	0.50%	1.93%	7.11%	0.03%	0.23%
P4	p value	.3752	0.0409**	.6974	.3416	0.0015**	.9637	.9263	0.0293**	.2240
	Percent Variance	2.30%	1.58%	0.17%	2.58%	3.48%	0.02%	0.03%	1.79%	0.73%
Pz	p value	0.0185**	.4420	.8903	0.0305**	0.0070**	.2145	.4808	.0836	.4781
	Percent Variance	15.41%	0.35%	0.05%	11.58%	3.55%	1.04%	1.42%	1.43%	0.41%
T3	p value	.1018	.4291	.9673	0.0400**	.8032	.4864	.3738	.4739	.9831
	Percent Variance	7.42%	0.49%	0.02%	11.28%	0.13%	0.44%	2.30%	0.41%	0.01%
T4	p value	.3836	.4465	.8866	.2957	.7300	.4569	.8571	.8974	.1257
	Percent Variance	2.19%	0.46%	0.07%	3.20%	0.16%	0.40%	0.09%	0.06%	1.14%
T5	p value	.1431	.1422	.0603	.0674	.0623	.0992	.0764	0.0202**	.3865
	Percent Variance	6.26%	0.81%	1.18%	9.30%	1.36%	1.12%	8.75%	1.96%	0.45%
T6	p value	.7942	.0660	.6618	.7219	0.0027**	.9098	.7413	0.0076**	.1145
	Percent Variance	0.21%	1.20%	0.17%	0.37%	2.84%	0.04%	0.31%	2.81%	1.19%

Note. Amplitude N200 data for each of the eighteen locations with gender as group categories.

Percent variance calculated using the R-Squared method.

** significance.

Table 10 shows the P300 amplitude data for comparisons of males vs menstrual phases. In the males vs menses phase comparison, there was no significance at any of the locations for group or G by C interaction; however, eleven of the eighteen locations reached significance for COND (values varied by location, refer to Table 10 for specifics). In the males vs ovulation phase comparison, there was also no significance at any of the locations for group, but a significant interaction for G by C was reached at location Pz ($p = .0195$). In addition, fifteen of the eighteen locations were significant (refer for Table 10 for specific values). In the males vs post-ovulation phase, there was no significance at any of the locations for group or G by C interaction; significance was reached at sixteen of the eighteen locations for COND (refer to Table 10 for specific values).

Table 10. Summary of Two-Way MANOVA Results for P300 Amplitude by Location.

		Male vs Menses			Male vs Ovulation			Male vs Post Ovulation		
Location:		Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C
C3	p value	.4579	.0828	.2368	.2681	0.0361**	.4792	.6135	0.0049**	.7314
	Percent Variance	1.53%	1.57%	0.89%	2.99%	3.06%	0.65%	0.76%	2.49%	0.13%
C4	p value	.9190	.4496	.2130	.9011	.4025	.3086	.7470	0.0059**	.5305
	Percent Variance	0.03%	0.47%	0.92%	0.04%	0.76%	0.98%	0.32%	1.97%	0.22%
F3	p value	.9821	0.0002**	.3810	.6730	<.0001**	.8533	.6766	<.0001**	.3775
	Percent Variance	0.00%	5.99%	0.58%	0.34%	15.36%	0.16%	0.45%	12.52%	0.44%
F4	p value	.9888	.1606	.2948	.8500	0.0089**	.6054	.5299	<.0001**	.4641
	Percent Variance	0.00%	1.36%	0.90%	0.08%	5.74%	0.57%	1.06%	6.51%	0.44%
F7	p value	.6293	0.0279**	.2511	.9931	0.0001**	.6843	.6868	<.0001**	.7000
	Percent Variance	0.58%	3.23%	1.20%	0.00%	12.68%	0.45%	0.43%	7.84%	0.20%
F8	p value	.4739	.0535	.2255	.8468	0.0079**	.6077	.4622	<.0001**	.9797
	Percent Variance	1.23%	2.84%	1.41%	0.08%	5.71%	0.54%	1.36%	8.11%	0.01%
Fp1	p value	.8209	0.0003**	.6630	.4123	<.0001**	.4395	.4393	<.0001**	.4128
	Percent Variance	0.14%	5.27%	0.24%	1.31%	11.81%	0.90%	1.64%	8.26%	0.38%
Fp2	p value	.4706	0.0086**	.1259	.6964	0.0009**	.7683	.6364	<.0001**	.7649
	Percent Variance	1.44%	2.88%	1.20%	0.35%	7.49%	0.25%	0.62%	7.28%	0.12%
Fz	p value	.7884	0.0032**	.5855	.3186	0.0001**	.6971	.4593	<.0001**	.1608
	Percent Variance	0.19%	4.52%	0.38%	1.91%	11.67%	0.41%	1.52%	8.72%	0.70%
O1	p value	.4965	<.0001**	.2558	.2217	<.0001**	.3987	.3297	<.0001**	.4844
	Percent Variance	1.13%	13.47%	0.77%	3.90%	7.69%	0.50%	2.08%	11.07%	0.63%
O2	p value	.7838	0.0149**	.9847	.5630	0.0047**	.7018	.6755	0.0200**	.7960
	Percent Variance	0.14%	6.32%	0.02%	0.83%	4.84%	0.29%	0.46%	3.12%	0.17%
P3	p value	.8520	<.0001**	.8620	.9430	0.0004**	.9809	.5447	0.0001**	.7983
	Percent Variance	0.10%	4.22%	0.05%	0.02%	3.60%	0.01%	1.09%	4.02%	0.09%
P4	p value	.7552	.6954	.4281	.5918	.2208	.6183	.6448	.5801	.6168
	Percent Variance	0.23%	0.39%	0.91%	0.75%	1.28%	0.40%	0.63%	0.29%	0.26%
Pz	p value	.4707	<.0001**	.0714	.5971	<.0001**	0.0195**	.5915	0.0020**	.4206
	Percent Variance	1.25%	8.53%	1.96%	0.77%	6.44%	1.83%	0.75%	4.73%	0.60%
T3	p value	.2296	0.0301**	.4189	.1014	0.0022**	.4324	.6350	0.0007**	.7969
	Percent Variance	3.19%	3.90%	0.92%	5.48%	7.21%	0.90%	0.62%	4.72%	0.13%
T4	p value	.4462	.2511	.7769	.2033	.3458	.4905	.4837	0.0122**	.8828
	Percent Variance	1.28%	1.68%	0.30%	3.39%	1.36%	0.90%	1.34%	3.03%	0.08%
T5	p value	.5363	<.0001**	.9234	.6799	<.0001**	.7102	.8851	<.0001**	.6244
	Percent Variance	0.79%	18.02%	0.06%	0.41%	11.25%	0.24%	0.04%	17.24%	0.40%
T6	p value	.9389	.2657	.3899	.8857	0.0157**	.9931	.3888	.1166	.5867
	Percent Variance	0.01%	1.93%	1.37%	0.05%	3.31%	0.01%	2.29%	0.77%	0.19%

Note. Amplitude P300 data for each of the eighteen locations with gender as group categories.

Percent variance calculated using the R-Squared method.

** significance.

The results for LN amplitude by location are displayed in Table 11. In the males vs menses phase comparison, group was significant at locations F7 (p = .0278), O1 (p = .0155), O2 (p = .0494), T3 (p = .0106), and T4 (p = .0340); COND was significant at eleven of the eighteen locations (refer to Table 11 for specific values); and G by C interaction was significant for locations F3 (p = .0279), Fp2 (p = .0022), Pz (p = .0159), T5 (p = .0260). In the males vs ovulation phase comparison, group was significant at locations O1 (p = .0120), O2 (p = .0284), Pz (p = .0156), and T3 (p = .0037); COND was significant at eleven of the eighteen locations (refer to Table 11 for specifics); and G by C interaction was significant at Pz (p = .0029) and T5 (p = .0076) locations. In the males vs post-ovulation phase, group was significant at three locations (O1 p = .0127, O2 p = .0134, and Pz p = .0113); COND was significant at fourteen locations (see Table 11 for specific values); and G by C interaction was significant at location Pz (p = .0025).

Table 11. Summary of Two-Way MANOVA Results for LN Amplitude by Location.

		Male vs Menses			Male vs Ovulation			Male vs Post Ovulation		
Location:		Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C
C3	p value	.1662	.0505	.2750	.3272	0.0265**	.2735	.3000	0.0029**	.3143
	Percent Variance	4.57%	2.78%	1.17%	2.42%	3.03%	1.04%	2.70%	4.79%	0.87%
C4	p value	.1464	0.0319**	.3024	.6266	.0508	.4058	.5910	0.0175**	.5150
	Percent Variance	4.89%	3.39%	1.13%	0.55%	3.21%	0.94%	0.75%	3.30%	0.51%
F3	p value	.0669	0.0042**	0.0279**	.1743	0.0007**	.2286	.5101	0.0030**	.3000
	Percent Variance	6.31%	6.66%	4.21%	3.46%	9.47%	1.74%	0.84%	7.77%	1.48%
F4	p value	.0861	.1103	.2035	.2075	.1071	.8279	.3998	.0999	.8499
	Percent Variance	7.37%	1.73%	1.24%	3.88%	2.09%	0.17%	1.86%	1.85%	0.13%
F7	p value	0.0278**	.1329	.2402	.1294	.1479	.1699	.3275	.0540	.6317
	Percent Variance	7.61%	3.28%	2.29%	4.12%	2.81%	2.60%	1.82%	4.24%	0.64%
F8	p value	.0536	.0689	.3586	.2506	.1915	.6056	.5054	.0966	.6802
	Percent Variance	8.24%	2.79%	1.04%	3.10%	1.72%	0.51%	1.08%	2.32%	0.37%
Fp1	p value	.2840	.3318	.1921	.5548	.0512	.0670	.6449	0.0483**	.4038
	Percent Variance	2.03%	1.71%	2.59%	0.56%	4.80%	4.35%	0.40%	4.50%	1.30%
Fp2	p value	.0781	.2733	0.0022**	.1780	.0794	.0671	.7196	0.0329**	.3546
	Percent Variance	6.51%	1.31%	6.75%	3.76%	2.99%	3.20%	0.30%	3.49%	1.02%
Fz	p value	.0609	.1781	.4529	.2288	0.0420**	.5693	.5020	.1124	.7071
	Percent Variance	6.54%	2.45%	1.11%	2.85%	4.31%	0.73%	0.97%	2.73%	0.42%
O1	p value	0.0155**	<.0001**	.7140	0.0120**	<.0001**	.7702	0.0127**	<.0001**	.7865
	Percent Variance	12.21%	19.45%	0.17%	16.04%	8.21%	0.10%	14.98%	12.33%	0.09%
O2	p value	0.0494**	<.0001**	.6581	0.0284**	<.0001**	.5262	0.0134**	<.0001**	.3908
	Percent Variance	8.19%	14.98%	0.29%	10.78%	12.15%	0.40%	13.60%	11.84%	0.57%
P3	p value	.6805	0.0008**	.5210	.3369	0.0016**	.4700	.9630	0.0003**	.7292
	Percent Variance	0.31%	10.25%	0.84%	2.13%	6.41%	0.68%	0.00%	9.64%	0.32%
P4	p value	.6046	<.0001**	.1638	.6040	<.0001**	.6203	.4960	<.0001**	.4809
	Percent Variance	0.41%	14.67%	2.51%	0.48%	14.93%	0.56%	0.83%	15.17%	0.83%
Pz	p value	.2130	<.0001**	0.0159**	0.0156**	<.0001**	0.0029**	0.0113**	<.0001**	0.0025**
	Percent Variance	2.42%	21.39%	4.45%	11.34%	16.62%	4.15%	10.91%	19.62%	5.00%
T3	p value	0.0106**	0.0227**	.2370	0.0037**	.0559	.1592	.0981	0.0135**	.5378
	Percent Variance	13.48%	3.99%	1.45%	16.37%	3.20%	2.00%	5.94%	4.74%	0.64%
T4	p value	0.034**	0.0295**	.7515	.4355	0.0353**	.7354	.5584	0.0092**	.9893
	Percent Variance	8.54%	4.70%	0.36%	1.32%	4.03%	0.35%	0.74%	5.63%	0.01%
T5	p value	.9722	<.0001**	0.0260**	.8494	<.0001**	0.0076**	.7301	<.0001**	.1834
	Percent Variance	0.00%	21.35%	3.27%	0.09%	12.20%	2.90%	0.25%	19.61%	1.13%
T6	p value	.4577	<.0001**	.2735	.9168	<.0001**	.6145	.4012	<.0001**	.2671
	Percent Variance	0.92%	19.94%	1.39%	0.02%	15.30%	0.48%	1.53%	13.80%	1.04%

Note. Amplitude late negative (LN) data for each of the eighteen locations with gender as group categories.

Percent variance calculated using the R-Squared method.

** significance.

Latency results for component N200 were reviewed in further detail due to the levels of significance reached at the multivariate level (refer to Table 4). Table 12 shows the N200 latencies for the male vs menstrual phase comparisons by location. There were no significant group effects for the males vs menses comparison; however, eleven of the locations reached significance for COND (refer to Table 12 for specific values) and location P3 ($p = .0143$) had a significant G by C interaction. In the males vs ovulation phase comparison, group was significant at locations P3 ($p = .0471$) and Pz ($p = .0163$); COND was significant at nine of the eighteen locations (refer to Table 12 for specifics); and G by C interaction was significant at P3 ($p = .0315$). Finally, in the males vs post-ovulation phase comparison, group was significant at location C4 ($p = .0464$); at eleven of the eighteen locations for COND; however, there were no significant G by C interactions.

Table 12. Summary of Two-Way MANOVA Results for N200 Latencies by Location.

		Male vs Menses			Male vs Ovulation			Male vs Post Ovulation		
Location:		Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C	Group (G)	COND (C)	G by C
C3	p value	.9239	.3209	.2851	.7578	0.0349**	.7613	.9640	0.0024**	.8462
	Percent Variance	0.02%	1.74%	1.92%	0.20%	4.26%	0.33%	0.00%	7.70%	0.19%
C4	p value	.0819	0.0057**	.2861	.1307	0.0090**	.5526	0.0464**	0.0253**	.2164
	Percent Variance	5.64%	6.91%	1.56%	4.94%	5.27%	0.62%	7.65%	4.66%	1.87%
F3	p value	.5932	0.0011**	.2316	.2902	0.0437**	.5657	.3999	0.0002**	.4751
	Percent Variance	0.54%	9.27%	1.82%	2.27%	4.10%	0.71%	1.45%	10.47%	0.78%
F4	p value	.9149	0.0336**	.6124	.9793	0.0364**	.2807	.6970	0.0389**	.1839
	Percent Variance	0.02%	5.49%	0.75%	0.00%	4.15%	1.54%	0.34%	3.65%	1.85%
F7	p value	.3054	0.0018**	.8946	.4872	0.0058**	.6916	.4944	0.0007**	.3688
	Percent Variance	1.90%	9.23%	0.15%	1.00%	6.47%	0.43%	0.86%	10.19%	1.25%
F8	p value	.4278	0.0015**	.6795	.6733	0.0030**	.3597	.4583	0.0008**	.5345
	Percent Variance	1.11%	9.75%	0.52%	0.40%	6.32%	1.02%	0.99%	10.37%	0.81%
Fp1	p value	.8573	.0779	.3622	.7322	.0516	.3888	.7186	0.0014**	.9585
	Percent Variance	0.07%	3.42%	1.33%	0.24%	3.87%	1.19%	0.25%	8.96%	0.05%
Fp2	p value	.5854	0.0056**	.9892	.5937	0.0162**	.5842	.5325	0.0103**	.7547
	Percent Variance	0.48%	8.76%	0.02%	0.56%	5.64%	0.69%	0.80%	5.98%	0.34%
Fz	p value	.2843	0.036**	.9725	.2138	.2589	.8035	.4317	0.0146**	.6126
	Percent Variance	2.08%	5.11%	0.04%	2.71%	2.20%	0.35%	1.17%	6.11%	0.66%
O1	p value	.0917	0.0019**	.8335	.0981	0.0064**	.7596	.3897	0.0003**	.7161
	Percent Variance	6.04%	7.06%	0.18%	6.50%	4.60%	0.23%	1.76%	7.68%	0.27%
O2	p value	.4822	0.0223**	.1393	.0999	0.0060**	.4681	.8284	0.0002**	.8241
	Percent Variance	0.93%	5.31%	2.66%	5.54%	6.12%	0.84%	0.10%	10.13%	0.20%
P3	p value	.2897	.9860	0.0143**	0.0471**	.4010	0.0315**	.1525	.2839	.5412
	Percent Variance	3.02%	0.01%	2.97%	10.35%	0.55%	2.17%	4.92%	1.21%	0.58%
P4	p value	.1979	.4232	.4344	.2390	.1411	.5103	.4675	.8913	.7617
	Percent Variance	2.97%	1.35%	1.31%	2.98%	2.38%	0.80%	1.13%	0.15%	0.36%
Pz	p value	.0847	.7856	.4187	0.0163**	.9813	.5728	.4931	.6831	.4092
	Percent Variance	7.12%	0.23%	0.82%	13.44%	0.02%	0.51%	1.41%	0.17%	0.41%
T3	p value	.4450	0.0483**	.2637	.4973	.4871	.2924	.3391	.0878	.1226
	Percent Variance	0.96%	5.04%	2.15%	0.92%	1.00%	1.72%	1.38%	4.25%	3.64%
T4	p value	.8672	.1095	.3033	.8241	.2365	.8884	.6100	.0598	.0869
	Percent Variance	0.05%	3.73%	1.98%	0.12%	1.62%	0.13%	0.48%	4.05%	3.49%
T5	p value	.4795	0.0099**	.8044	.4058	.0657	.8492	.6420	.0796	.8710
	Percent Variance	1.22%	4.40%	0.19%	1.73%	2.48%	0.14%	0.44%	3.50%	0.18%
T6	p value	.9943	.3380	.7137	.2810	.4569	.4071	.8076	.2294	.8592
	Percent Variance	0.00%	1.55%	0.48%	2.62%	0.89%	1.02%	0.13%	1.92%	0.19%

Note. Latency N200 data for each of the eighteen locations with gender as group categories.

Percent variance calculated using the R-Squared method.

** significance

Discussion

Reaction Time

Analyses revealed no significant differences for RT between menstrual phases; thus there is no support for the original hypothesis that RT would vary across the menstrual cycle. This supports some previous studies on menstruation where RT on cognitive tasks was also not significant (e.g., Amin, 2006; Kluck et al., 1992; O'Reilly et al., 2004; Tasman, Hahn, & Maiste, 1999; Walpurger et al., 2004). In addition, there were no significant differences for RT between genders. This indicates that all participants (males and females in each menstrual phase) were equally attending to the visual stimuli within the task.

Grand-averaged VEPs

In the adopted object recognition task, the late components of the VEP waveform were differentially altered by the behavioral task. The P300 amplitude of the VEP was enhanced in association with the Relevant stimulus. This result was expected, partly based on previous studies (Stefffensen et al., 2008), and the fact that the P300 amplitude is known to be dependent on the allocation of attentional resources, as well as target salience, or the degree to which an object pops-out from a background of distractor stimuli (Coull, 1998; Katayama & Polich, 1998; Picton, 1992). There are two main types of visual object search: parallel and serial (Luck & Hillyard, 1994). Parallel, or "pre-attentive," processing occurs when an object contains one or more features that are absent from the distractors in the scene, causing an object to "pop-out" from a background of homogeneous distractors (Bravo & Nakayama, 1992; Dehaene, 1989; Egeth, Jonides, & Wall, 1972; Nakayama & Silverman, 1986; Saarinen, 1997; Theeuwes, 1993; A.

Treisman & Gormican, 1988; A. M. Treisman & Gelade, 1980; Verghese & Nakayama, 1994; Wolfe, 1994). Parallel processing is distinguished by a relatively short RT latency when compared to the longer latencies of serial processing due to distractor stimuli (Duncan & Humphreys, 1989; Saarinen, 1997; Salyer, 2001; Theeuwes, 1993; A. M. Treisman & Gelade, 1980; Wolfe, 1994).

In the visual processing paradigm used in the present study, P300 amplitudes associated with the Relevant and Irrelevant stimuli were greater in females than males, supporting our previous studies (Steffensen et al., 2008) and those of others (Chu, 1987; Hoffman & Polich, 1999) demonstrating that event-related potentials (ERPs) are sensitive to gender. The relationship between gender and the P300 has been controversial as some studies see no gender bias. For example, Oliver-Rodriguez, et al. (1999) looked at facial attractiveness and the emotional component and found that P300 amplitudes were greater in male participants. Although, in separate studies, females were found to have larger P300 components when evaluating emotion presented in faces (Morita, Morita, Yamamoto, Waseda, & Maeda, 2001; Yamamoto, et al., 2000). Considering these contradictory findings, researchers have looked for factors that could help explain the dichotomy between gender VEP components. One hypothesis that has been proposed explains that head size and geometry may account for more of the difference between gender VEPs than actual biological and physiological differences (Guthkelch, Bursick, & Sclabassi, 1987). Other possible explanations for the gender difference are seasonal variation (Deldin, Duncan, & Miller, 1994) and emotion (Morita, et al., 2001; Yamamoto, et al., 2000). Finally, it has recently been proposed that hemispheric asymmetry might give rise to greater P300 amplitudes in females than males (Roalf,

Lowery, & Turetsky, 2006). If the brains of men are typically more lateralized than those of women (Kolb & Wilshaw, 1996), women should evince more symmetrical processing of visual stimuli than men. In the present visual recognition task, the grand-averaged VEP data showed clear asymmetry of P300 amplitudes in association with the Relevant stimulus while the N100 component was not asymmetrical, indicating pronounced laterality with event-related potentials but not evoked potentials. P300 amplitude is generally associated with stimulus probability, which was the same across phase of the menstrual cycle and gender in this study, by task salience, which was also the same across these conditions, and by attentional resources. Therefore, these findings suggest that women allocated greater attentional resources towards, and/or attributed greater task salience to the distracting (i.e., Irrelevant) stimuli than men. These findings support the prevailing hypothesis that the P300 is sensitive to gender. This obtains despite the lack of differences in the early components of the VEP and in RT between males and females, suggesting that sensory processing and motor performance do not contribute to the differences.

Menstrual Phase Comparisons

The results of the menstrual phase comparisons show vast amounts of variability among the VEP components amplitudes and latencies. Specific analyses showed that some components appear to vary by overall location areas; for example, with the P200 amplitude and latency significant data for menstrual phase comparisons clustered around the frontal EEG locations (F3 through Fz), corresponding to the frontal lobe area (see Tables 5 and 8). P200 component data was not part of the original hypothesis for this study; however, multivariate significance revealed that this component varied across

menstrual phases with participants in this study. When means are compared for the P200 data, it appears that the menses phase is associated with larger P200 amplitudes than the ovulation or post-ovulation phases at these locations (e.g., F3 menses M = 2.69, ovulation M = .69, and post-ovulation M = .55). Latency means show that P200 peaks later during the menses phase (F3 M = 228.71) than during the ovulation (F3 M = 209.33) or post-ovulation (F3 M = 212.89) phases. These trends are consistent throughout the frontal locations. This suggests that P200 amplitudes are larger and occur later during the menses phase than during the ovulation or post-ovulation phases. The menses phase is associated with low levels of estrogen, LH, and progesterone; however, how these hormone levels may impact this particular component is unclear.

There was modest support for the original hypothesis that P300 and LN components vary across menstrual phases with multivariate significance reached with group by condition amplitude data ($p = .0211$ for P300 and $p = .0144$ for LN). However, there was no significance between menstrual phases themselves for the P300 or LN components. In addition, the P300 component reached significance ($p = .0126$) in the group by condition comparison for latency data; however, the LN did not and neither component reached significance for the menstrual phase comparison. This supports the visual information obtained in Figure 7, showing the P300 and LN components clustered together for the three menstrual phases (but clearly separate from the male group). It appears that amplitudes for P300 and LN components vary with regards to menstrual phase and type of stimuli and specific analyses for P300 and LN components would provide further insight. However, multivariate results for P200 and N200 amplitudes and

N100 and P200 latencies demonstrated significance across all effects and interactions and may be worth considering in addition to P300 and LN components in future studies.

Males vs Menstrual Phase Comparisons

Multivariate data clearly support VEP component differences between males and females in different phases of menstruation. Table 9 offers a nice summary of how these differences vary across menstrual phases, with group differences occurring in different locations depending upon phase (e.g., locations F3 and F7 are significant during male and menses, but not during male and ovulation or post-ovulation comparisons). It is also interesting to note, that no significant differences occur between males and females during the post-ovulation phase except for the interaction at location Fp1 for N200 amplitude. This might help explain why some previous studies focusing on the post-ovulation timeframe (between ovulation and menses phases) haven't found significant differences (e.g., Johnston & Wang, 1991; Garrett & Elder, 1984). Although, the differences found in this study could also clearly be task dependent.

Comparisons of P300 and LN amplitudes show a fair amount of consistency in location significance across menstrual phases (see Tables 10 and 11). Specifically, the LN component is significant at locations O1, O2, P3, P4, Pz, T3, T4, T5, and T6 across the menstrual phases. It is also interesting to note that P300 amplitudes are significant almost exclusively for stimuli type and support the visual information displayed earlier in the figures. Mean comparisons show that the P300 is larger in females than males regardless of menstrual phase type (for location O1: male Standard M = 1.43, Irrelevant M = 2.00, Relevant M = 2.91; menses phase Standard M = 1.65, Irrelevant M = 2.16, Relevant M = 3.89; ovulation phase Standard M = 2.37, Irrelevant M = 2.73, Relevant M

= 4.57; post-ovulation Standard M = 2.16, Irrelevant M = 2.14, Relevant M = 3.81) and that the Relevant stimuli produces a larger P300 than the Irrelevant and Standard stimuli in both genders. This supports previous findings of a larger P300 in female participants compared with males (Chu, 1987; Hoffman & Polich, 1999; Steffensen et al., 2008).

Methodology

A LH home-use urine test kit was used in this study due as a means of identifying hormone fluctuation due to its affordability and ease of use. There were some misunderstandings among a couple of the female participants regarding how to use and report ovulation that were caught early on in the study that may have impacted some of the participants who reported no ovulation. It is believed that the differences found between menstrual phases in this study represents the fluctuation of hormone levels during menstruation; specifically with the menses phase being associated with low levels of estrogen, LH, and progesterone; the ovulation phase being associated with increased levels of estrogen, peak levels of LH, and low levels of progesterone; and the post-ovulation phase being associated with increased levels of estrogen and progesterone and low levels of LH.

The three target menstrual phases used in this study were chosen mainly due to ease of identification. The menses phase is obviously the most easily identifiable of the three; however, ovulation was reported in 10 of the 15 analyzed participants and so the LH test is believed to be a fairly reliable method of identifying ovulation. Post-ovulation phases were determined by reviewing each participant's menstrual history. While the methods used to identify and group menstrual phases in this study weren't proposed as a means of improvement to methods used in previous studies; the data support that these

phases were well defined and that visual processing differences did occur across menstrual cycles at the time of the EEG recordings.

Study Limitations

As previously mentioned, five participants (two males and three females) were removed from analyses due to equipment malfunctions, high error rates, and reduced sampling rates. The ending sample size of sixteen males and fifteen females is small and the results found should be interpreted with caution. In addition, EEG recording sessions were conducted during the first two months of Fall Semester and with 21 of our 31 participants (11 males and 10 females) being students, the results could be influenced by variations in individual levels of stress as the semester progressed. Although menstrual phase grouping was an attempt to nullify the impact any extraneous variables may have had on this task.

The three-way term (group by person by COND) was left out of the three-way MANOVA model since there were no replications of conditions, so three-way interactions could not be analyzed for this study. In addition, there was no proper error term for conditions in this model and pseudo F-ratios were only calculated on univariate data.

Conclusions

Based on the initial analyses conducted in this study, it is clear that the results support visual processing differences across menstrual phases and support previous findings of gender differences using this same paradigm (Steffensen et al., 2008). Unlike the previous study, the N400 component was not distinctive with this data and therefore could not be compared across menstrual phases or between genders. However, there is

support that the LN component, as well as the P300 component, varies across the menstrual cycle and between genders. In addition, there is evidence that other VEP components (such as the P200 and N200) also vary across the menstrual cycle.

The differentiation found with VEP components in response to the pop-out task used in this study provide support for basic visual processing variation across the menstrual cycle and between genders. Future psychophysiological studies on cognitive differences across menstrual phases would do well to expand the number of target VEP components and to consider assessing ERP location differences.

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Appendix

Study Support Materials

This appendix contains the questionnaires and consent forms used with the participants of this study; both male and female versions are included were applicable. The advertisement flyers used to recruit participants are also included in this section.

Visual Attention, Color Processing and Physiological Measures
Pre-Qualification Screening Interview Questions

The purpose of this research is to study physiological measures, specifically brain activity measured by brain-wave tracings (using electroencephalography or EEG), during performance of computer-presented cognitive tasks. Male participants will be asked to participate in one physiological recording session, lasting approximately 30 to 60 minutes. Female participants will be asked to participate in three physiological recording sessions, each lasting approximately 30 to 60 minutes.

The following questions will be used to determine if you qualify as a participant for this research.

What is your name?

What is your gender?

What is your age?

Are you color-blind?

How would you rate your current overall health? (e.g., excellent, good, fair, poor)

Do you have a personal history of physiological disorders?

Do you have a personal history of psychological disorders?

Are you currently taking any type of medication? If so, what type(s)?

Female only:
Have you had normal menstrual cycles (defined as lasting between 25 to 35 days) for the past three months?

Are you currently pregnant or breastfeeding?

Have you been pregnant or breastfeeding during the previous three months?

Are you currently taking oral contraceptives?

Female participants will be given a home-use urine test kit and will be asked to test their urine once a day, beginning on day 8 of their menstrual cycle, to identify when ovulation occurs. Ovulation will need to be tested across one menstrual cycle during the physiological recording sessions.
Would you be opposed to using a home-use urine test kit?

In addition, female participants will be asked to participate in three physiological recording sessions during the month of ovulation testing; once during menstruation, once at ovulation, and once during post-ovulation/pre-menstruation phase. Menstruation history will be used to approximate physiological recording session timeframes; however, there is a possibility that one or more physiological recording sessions will need to occur with short-notice (for example, if a participant's ovulation phase occurs sooner or later than expected).
Are you available to participate during the next month and would your schedule permit possible short-notice physiological recording sessions (occurring within 24 hours of reported ovulation)?

Male and female:
If you are selected as a potential participant for this research additional information will be given to you and you will be asked to sign a "consent to be a research subject" form.

Do you have any questions at this time?

If you qualify, would you be interested in participating in this research?

May we have your contact information?

Thank you for your time and interest in this research study.

Visual Attention, Color Processing and Physiological Measures
Demographic Questionnaire

This box to be completed by staff

Research ID: _____

Name: _____

Gender (please check one): Female ____ Male ____

Age: _____

Race: _____

Marital Status: Single ___ Engaged ___ Married ___ Divorced ___ Widowed ___

Number of Children: _____ **Ages**: _____

Occupation: _____

Education (please check highest level attained):
High School ____
Some Undergraduate ____ Major/Minor: _____
Associates Degree ____ Major/Minor: _____
Bachelor's Degree ____ Major/Minor: _____
Some Graduate ____ Major/Minor: _____
Master's Degree ____ Major/Minor: _____
Doctorate ____ Major/Minor: _____
Trade School ____ Type: _____

Annual Household Income:
Under $10,000 ____
$10,001 - $30,000 ____
$30,001 - $60,000 ____
$60,001 - $90,000 ____
$90,001 - $120,000 ____
Over $120,001 ____

Primary Language: _____

Secondary Language(s): _____

Visual Attention, Color Processing and Physiological Measures
Medical Questionnaire

This box to be completed by staff

Name: _____ **Research ID**: _____

General Background

How do you view your present health? (Please check one)
Excellent ____ Good ____ Fair ____ Poor ____

If fair or poor, please explain: _____

_____

Are you under the care of a physician now? Yes ____ No ____

If yes, please explain: _____

_____

_____

Have you consulted or been treated by clinics, physicians, healers or other practitioners within the past year for other than minor illnesses? Yes ____ No ____

If yes, please explain: _____

_____

_____

Please list all medications that you are currently taking (including insulin, oral contraceptives, prescription medications, over-the-counter medications, vitamins, diet supplements, herbal supplements, etc.).

Medication:	Taken For:	Approximate Date Started:

Do you have vision in both eyes? Yes ____ No ____

Do you wear glasses or contact lenses? Yes ____ No ____

Right eye:
With glasses/contact lenses ____/20
Without glasses/contact lenses ____/20

Left eye:
With glasses/contact lenses ____/20
Without glasses/contact lenses ____/20

Are you color-blind? Yes ____ No ____

Have you had or do you have any other problems with your eyes or vision? Yes ____ No ____

If yes, please explain: _____

_____

_____

Personal Medical History

Have you ever been hospitalized? Yes ____ No ____

If yes, please explain: _____

_____

_____

Have you ever had any surgeries (in-patient or out-patient)? Yes ____ No ____

If yes, please explain: _____

_____

_____

Please check if you have had or currently have any of the following conditions:

____ Lightheadedness/dizziness
____ Loss of consciousness/fainting
____ Seizures or epilepsy
____ Frequent headaches
____ Head injury/brain trauma
____ Abnormal EEG
____ Memory problems
____ Numbness or tingling of arms, legs, or face
____ Weakness of an arm, leg or other part of body
____ Stroke
____ Paralysis
____ Decrease in vision
____ Double vision
____ Glaucoma
____ Color blindness
____ Cataracts
____ Serious injury to eye
____ Difficulty sleeping
____ Psychiatric or psychological disorder (Please explain: _____)
____ Claustrophobia
____ Drug or alcohol abuse
____ Other (Please explain: _____)

Family Medical History

Please check if there is any history in your family of the following conditions and circle the appropriate relationship:

____ Lightheadedness/dizziness
Child Brother Sister Father Mother Grandfather Grandmother

____ Loss of consciousness/fainting
Child Brother Sister Father Mother Grandfather Grandmother

____ Seizures or epilepsy
Child Brother Sister Father Mother Grandfather Grandmother

____ Frequent headaches
Child Brother Sister Father Mother Grandfather Grandmother

____ Head injury/brain trauma
Child Brother Sister Father Mother Grandfather Grandmother

____ Abnormal EEG
Child Brother Sister Father Mother Grandfather Grandmother

____ Memory problems
Child Brother Sister Father Mother Grandfather Grandmother

____ Stroke
Child Brother Sister Father Mother Grandfather Grandmother

____ Paralysis
Child Brother Sister Father Mother Grandfather Grandmother

____ Psychiatric or psychological disorder
Child Brother Sister Father Mother Grandfather Grandmother

____ Drug or alcohol abuse
Child Brother Sister Father Mother Grandfather Grandmother

____ Other (Please explain: _____)
Child Brother Sister Father Mother Grandfather Grandmother

Women's Personal Health

Age at first menstrual period: _____

How long do your periods typically last? _____

How often do they occur (i.e., how many days between menstrual periods)?

_____

When did your last menstrual period begin? _____

What were the start dates of your previous three menstrual periods?

_____

_____

_____

Have you ever had a change in your menstrual pattern? Yes ____ No ____

If yes, please explain: _____

_____

Do you have any problems related to your periods? Yes ____ No ____

If yes, please explain: _____

_____

Have you ever been diagnosed with a menstrual disorder? (e.g., Amenorrhea, Dysmenorrhea, Menorrhagia, Metrorrhagia, Premenstrual Syndrome) Yes ___ No ___

If yes, please explain: _____

_____

Have you ever taken estrogen or female hormones? Yes ____ No ____

If yes, please explain: _____

_____

How many pregnancies have you had? _____

How many live births have you had? _____

How many living children do you currently have? _____

Are you currently pregnant or suspect you may be pregnant? Yes ____ No ____

Are you attempting to become pregnant? Yes ____ No ____

Have you been pregnant within the past 6 months? Yes ____ No ____

Are you currently breastfeeding? Yes ____ No ____

Have you breastfeed within the past 6 months? Yes ____ No ____

Visual Attention, Color Processing and Physiological Measures
Consent to be a Research Subject
(Male Subject)

Introduction
The purpose of this research is to study physiological measures, specifically brain activity, during the performance of computer-presented mental tasks. Graduate student, Michelle Nash, and Professor Scott Steffensen are the researchers for this project and will be assisted by several trained, undergraduate students. You have been asked to participate in this study because you are a healthy person and have indicated your interest in being a participant in a research project.

Procedures
Before the physiological measures are obtained, you will be asked to complete two questionnaires. The first questionnaire has 10 simple questions on your background (for example, your marital status and occupation); the second questionnaire has 24 questions on your medical history and your family's medical history and is similar to questionnaires you may have filled out at a doctor's office. It should take only 10-15 minutes to complete both of these questionnaires.

Next, you will be placed in a comfortable chair in a research room where a bonnet, or cap, containing electrodes will be placed on your head. It will take up to five minutes to properly place the electrode bonnet. You may experience some scalp discomfort or even minor pain while the electrodes are fitted. The electrodes will measure your brain activity in several locations as you relax and then as you perform several mental tasks presented to you on a computer. The mental tasks consist of identifying items that you will be asked to remember and will take approximately 20-30 minutes.

Please note that the data obtained will not be used for clinical purposes but simply for this research. That is, the data obtained will not be evaluated for the purposes of personal diagnosis or treatment of neurological disease, and this research procedure does not take the place of a clinical EEG procedure.

Risks/Discomforts
There are minimal risks involved in this type of study. The procedures are safe and non-invasive; that is, they simply measure electrical activity but do not themselves transmit electrical currents. Some people may, for example, feel some claustrophobia from the electrode bonnet and/or being in the dark. You also may experience some mental fatigue during the tasks.
You will be excluded from study participation if you have a history of *seizures, claustrophobia, fainting, or, brain trauma, or any physiological or psychological disorder, or if you are currently taking any long-term medication.* As mentioned above, the fitting of the electrode bonnet may involve some discomfort to your scalp or even minor pain. You will be carefully monitored throughout the procedures and may stop participating at any time if you become uncomfortable.

Benefits
There are no direct benefits to subjects for participation in this study. However, it is hoped that through your participation researchers may learn more about gender differences in visual attention and color processing. Furthermore, it is believed that this information can be used in the future to assist drug rehabilitation centers with identifying and determining treatment outcome measures in addicted patients.

Confidentiality
Strict confidentiality will be maintained. All information provided will remain confidential and will only be reported as group data with no identifying information. All data, including questionnaires and physiological measures will be kept in a locked storage cabinet and only those directly involved with the research will have access to them. The data obtained in this study will be kept for future research studies; however, your name will not be associated with any current or future study documents or publications.

Compensation
You will receive a $5 BYU bookstore gift card for your participation in this research study.

Participation
Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely without affecting your standing in class or at the university. There may be circumstances in which the participation of a research subject is terminated. These circumstances will be determined by the research team and may include equipment failure, scheduling problems, or if you meet any of the exclusion criteria.

Questions about the Research
If any questions or concerns arise, please feel at liberty to contact Ms. Michelle Nash at 615-3915 or michelle.nash@byu.net. You may also contact Dr Scott Steffensen at 422-9499 or scott_steffensen@byu.edu.

Questions about Your Right as a Research Participant
If you have any questions regarding your rights as a participant in a research project, you may contact Christopher Dromey, PhD, Chair of the Institutional Review Board for Human Subjects, 133 TLRB, Brigham Young University, Provo, UT 84602; phone, (801) 422-6461; e-mail, christopher_dromey@byu.edu.

I have read, understood, and received a copy of the above consent and desire of my own free will to participate in this study.

_____	_____
Name of Research Subject (Print)	Signature of Research Subject

_____	_____
Age	Date

Visual Attention, Color Processing and Physiological Measures
Consent to be a Research Subject
(Female Subject)

Introduction
The purpose of this research is to study physiological measures, specifically brain activity, during the performance of computer-presented mental tasks. Graduate student, Michelle Nash, and Professor Scott Steffensen are the researchers for this project and will be assisted by several trained, undergraduate students. You have been asked to participate in this study because you are a healthy person and have indicated your interest in being a participant in a research project.

Procedures
Before the physiological measures are obtained, you will be asked to complete two questionnaires. The first questionnaire has 10 simple questions on your background (for example, your marital status and occupation); the second questionnaire has 24 questions on your medical history and your family's medical history and is similar to questionnaires you may have filled out at a doctor's office. It should take only 10-15 minutes to complete both of these questionnaires.

In addition, you will be asked to document your menstrual cycle for one month. Specifically, you will be required to document the first day of each menstrual cycle and the onset of ovulation and consult researchers when these events occur. In addition, you will participate in a series of three physiological recording sessions.

During each recording session, you will be placed in a comfortable chair in a research room where a bonnet, or cap, containing electrodes will be placed on your head. It will take up to five minutes to properly place the electrode bonnet. You may experience some scalp discomfort or even minor pain while the electrodes are fitted. The electrodes will measure your brain activity in several locations as you relax and then as you perform several mental tasks presented to you on a computer. The mental tasks consist of identifying items that you will be asked to remember and will take approximately 20-30 minutes.

Please note that the data obtained will not be used for clinical purposes but simply for this research. That is, the data obtained will not be evaluated for the purposes of personal diagnosis or treatment of neurological disease, and this research procedure does not take the place of a clinical EEG procedure.

Risks/Discomforts
There are minimal risks involved in this type of study. The procedures are safe and non-invasive; that is, they simply measure electrical activity but do not themselves transmit electrical currents. Some people may, for example, feel some claustrophobia from the electrode bonnet and/or being in the dark. You also may experience some mental fatigue during the tasks. You will be excluded from study participation if you have a history of *seizures, claustrophobia, fainting, brain trauma, or any physiological or psychological*

disorder, if you are currently taking any long-term medication (excluding oral contraceptives), or are pregnant or breastfeeding. As mentioned above, the fitting of the electrode bonnet may involve some discomfort to your scalp or even minor pain. You will be carefully monitored throughout the procedures and may stop participating at any time if you become uncomfortable.

Benefits
There are no direct benefits to subjects for participation in this study. However, it is hoped that through your participation researchers may learn more about gender differences and hormonal variation in visual attention and color processing. Furthermore, it is believed that this information can be used in the future to assist drug rehabilitation centers with identifying and determining treatment outcome measures in addicted patients.

Confidentiality
Strict confidentiality will be maintained. All information provided will remain confidential and will only be reported as group data with no identifying information. All data, including questionnaires and physiological measures will be kept in a locked storage cabinet and only those directly involved with the research will have access to them. The data obtained in this study will be kept for future research studies; however, your name will not be associated with any current or future study documents or publications.

Compensation
You will receive $25 for each physiological recording session, for a maximum of $75, which will be given at the end of your research participation. If you are unable to complete all of the physiological recording sessions, you will receive $25 for each attended session (i.e., if you attend one physiological recording session you will receive $25; if you attend two physiological recording sessions you will receive $50).

Participation
Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely without affecting your standing in class or at the university. There may be circumstances in which the participation of a research subject is terminated. These circumstances will be determined by the research team and may include equipment failure, scheduling problems, or if you meet any of the exclusion criteria.

Questions about the Research
If any questions or concerns arise, please feel at liberty to contact Ms. Michelle Nash at 615-3915 or michelle.nash@byu.net. You may also contact Dr Scott Steffensen at 422-9499 or scott_steffensen@byu.edu.

Questions about Your Right as a Research Participant
If you have any questions regarding your rights as a participant in a research project, you may contact Christopher Dromey, PhD, Chair of the Institutional Review Board for

Human Subjects, 133 TLRB, Brigham Young University, Provo, UT 84602; phone, (801) 422-6461; e-mail, christopher_dromey@byu.edu.

I have read, understood, and received a copy of the above consent and desire of my own free will to participate in this study.

_____ _____

Name of Research Subject (Print) Signature of Research Subject

_____ _____

Age Date

Male Research Participants Needed!!!

Purpose of Research:

To study gender differences on physiological measures during the performance of computer-presented visual attention and color processing tasks.

If you are:

- **18 to 30 years old**
- **Not color-blind**
- **In good overall health**
- **With no history of physiological or psychological disorders**

Participants will be asked to participate in one physiological recording session, lasting approximately 1 hr.

Earn a $5.00 gift card for completing a 1 hr EEG session!

Please contact Michelle Nash at 801-615-XXXX or at michelle.nash@byu.net for more information.

Research Participants Needed!!!

Purpose of Research:

To study gender differences and menstrual effects on physiological measures during the performance of computer-presented visual attention and color processing tasks. The short-term objective of this study is to determine if phases of the menstrual cycle influence cognitive and color processing in drug-free control subjects. The long-term objective is to determine if cognitive and color processing is disrupted in narcotic addicts.

If you are:

- **A woman**
- **18 to 30 years old**
- **Not color-blind**
- **In good overall health**
- **With no history of physiological or psychological disorders**
- **No recent history of drug abuse**
- **With normal menstrual cycles (lasting 25 to 35 days)**
- **Not pregnant or breastfeeding for the past 6 months**

Participants will be asked to participate in three physiological recording sessions, each lasting approximately 30 to 60 minutes, and will need to be available for two months.

Earn $75.00 for completion of three 1 hr EEG sessions!

Please contact Michelle Nash at 801-378-XXXX or at michelle.nash@byu.net for more information.